Salmon and Steelhead Habitat Limiting Factors Report for the Foster and Moses Coulee Watersheds

Water Resource Inventory Areas (WRIA) 50 and 44

FINAL REPORT

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AGENCY, ORGANIZATIONAL, AND OTHER ABBREVIATIONS

ACOE	Army Corps of Engineers
BLM	United States Bureau of Land Management
BPA	Bonneville Power Administration
CCCD	Chelan County Conservation District
CCT	Colville Confederated Tribes
CRITFC	Columbia River Inter-tribal Fish Commission
DNR	Washington Department of Natural Resources
EPA	United States Environmental Protection Agency
FCCD	Foster Creek Conservation District
GCFMP	Grand Coulee Fish Management Plan
GIS	Geographic Information Systems
HPA	Hydraulic Project Approval
HUC	Hydrologic Unit Code
NFH	National Fish Hatchery
NMFS	National Marine Fisheries Service
NPPC	Northwest Power Planning Council
NWIFC	Northwest Indian Fisheries Commission
SaSI	Salmonid Stock Inventory
SASSI	Washington State Salmon and Steelhead Stock Inventory
TAG	Technical Advisory Group
USFS	United States Forest Service, Department of Agriculture
USFWS	United States Fish and Wildlife Service, Department of Interior
USGS	United States Geological Survey
WAC	Washington Administrative Code
WCC	Washington Conservation Commission
WDOE	Washington Department of Ecology
WDF	Washington Department of Fisheries (superceded by WDFW)
WDW	Washington Department of Wildlife (superceded by WDFW)
WDFW	Washington Department of Fish and Wildlife
WRIA	Water Resource Inventory Area
WSDA	Washington State Department of Agriculture
WDOT	Washington State Department of Transportation
YIN	Yakama Indian Nation (superceded by YN)
YN	Yakama Nation

UNITS OF MEASUREMENT

°C	Degrees Celsius	ffp	fish per pound
cm	Centimeter	°F	Degrees Fahrenheit
DO	Dissolved oxygen	RM	River Mile
m^3/s	Cubic meters per second	TMDL	Total Maximum Daily Load
ha	Hectare	km^2	Square Kilometer
m	Meter	km	Kilometer
mbf	million board feet	MP	mile post

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EXECUTIVE SUMMARY

The Foster Water Resource Inventory Area (WRIA) 50 and Moses Coulee Water Resource Inventory Area (WRIA) 44 are located close to the geographic center of Washington State in the “Big Bend” area of the Columbia River. The Foster WRIA 50 drains an approximate 334 square mile watershed (213,639 acres) in northern Douglas County. In WRIA 50, East, Middle, and West Foster Creek converge and flow northward emptying into the Columbia River downstream of Chief Joseph Dam (Columbia River Mile 545.1) near the town of Bridgeport. A small portion of WRIA 50 lies within Okanogan County and drains directly into the Columbia River. The Moses Coulee WRIA 44 drains an approximate 1,213 square mile watershed (776,222 acres). Moses Coulee extends southwest from central Douglas County before emptying into the Columbia River (Columbia River Mile 447.0). A small portion of WRIA 44 lies within Grant County. Portions of WRIA 50 and 44 outside of Douglas County are not addressed in this report. Small sections of WRIA 40 and WRIA 42 fall within Douglas County that are not addressed in the report.

Water Resource Inventory Areas 50 and 44 lie within the Upper Columbia River Salmon Recovery Region called an Evolutionarily Significant Unit (ESU) by the National Marine Fisheries Service (NMFS) and a Distinct Population Segment (DPS) by the U.S. Fish and Wildlife Service (USFWS), the two federal agencies charged with protecting and restoring species listed under the federal Endangered Species Act (ESA). Summer/fall-run chinook salmon that occur in the Upper Columbia (ESU) are not listed under the ESA. However, the Methow and Okanogan River stocks are designated “depressed” in the Washington State 1992 Salmon and Steelhead Stock Inventory (SASSI); the Wenatchee summer/fall-run chinook stock is designated “healthy”. Neither of the two sockeye salmon runs that occur in the Upper Columbia ESU are listed under the ESA. Both the Lake Osoyoos (Okanogan Watershed) and the Lake Wenatchee sockeye stocks are designated “healthy” in the SASSI. Coho salmon have been extirpated from the upper Columbia River region and are not addressed in the SASSI or under the ESA. Summer steelhead within the Upper Columbia ESU were listed under the Endangered Species Act (ESA) as “Federally Endangered” on August 18, 1997. Spring-run chinook salmon within the Upper Columbia ESU were listed under the ESA as “Federally Endangered” on March 24, 1999. Bull trout in the Upper Columbia DPS were listed under the ESA as “Federally Threatened” on June 10, 1998. All of these salmonid species (except the extirpated coho salmon) presently utilize the upper Columbia River, which forms the western boundary of Douglas County and cuts through the northern portion of WRIA 50, separating the WRIA in Douglas and Okanogan counties. To a very limited extent, both summer steelhead and chinook also utilize some tributaries of WRIA 50 and 44 (Foster Creek, Corbaley Canyon, Sand Canyon, Rock Island Creek and Moses Coulee).

The Salmon and Steelhead Habitat Limiting Factors Report for the Foster and Moses Coulee Watersheds focuses on habitat conditions in the watersheds as they affect the ability of habitat to sustain naturally producing salmonid populations. The report briefly discusses salmon and steelhead use in the Columbia River, but acknowledges the river is being addressed on a regional level and is outside the scope of this document. It provides a snapshot in time based on data and published material available during the development of this report and the knowledge of technical fish experts and landowners serving as the Technical Advisory Group (TAG). Although revisions to the report are not currently funded, the Washington State Conservation Commission (WCC) will be requesting funding in the 2001-2003 budget for a continuation in funding to allow for this need.

Data in the literature on habitat conditions in the watersheds is extremely limited. As pointed out by those reviewing the report, conclusions within the existing literature often lack adequate supporting data and in some cases are contradictory. Thus, the report relies heavily on professional and local knowledge to identify salmonid distribution and habitat impairments, and to assess the extent to which habitat conditions are negatively affecting salmonid use in the watershed.

Factors Affecting Natural Salmonid Production in the Watershed

Salmon distribution and productivity in the Foster and Moses Coulee Watersheds is naturally limited by the lack of hydrology to support year round flows in most drainages. In the arid, shrub-steppe environment, most steams are seasonal, feed by spring runoff or intense summer storm events, or are intermittent, feed by a spring system. Some years there are perennial flows in some streams, but this hydraulic continuity is unlikely year-round (TAG 10-30-00). Human alterations to the environment can exacerbate these natural low flow conditions, reducing habitat access, quantity, and quality.

Fish passage barriers (such as irrigation diversion dams and culverts) limit fish distribution and use to generally the first mile of streams in the Foster and Moses Coulee watersheds. Given the natural lack of hydrology, it is uncertain to what extent these streams may once have supported salmonid productivity beyond the first mile or so even prior to human disturbance in the watersheds, although it is believed to be minimal (TAG 10-30-00). Studies are needed that would assist in the evaluation of instream flows as they relate to changes in wetland functions, floodplain functions, groundwater/surface water interactions, and upland vegetation changes in the watersheds. Information generated by these studies would contribute to making more informed conclusions about the extent to which human-created fish passage barriers limit salmonid distribution and use beyond those limitation already imposed by the seasonal nature of flows in WRIA 50 and 44.

Stream channels and riparian conditions have been drastically altered by flood events and human activity. The extent to which these alterations impact salmonid distribution and productivity is uncertain, given the natural limitations to distribution and productivity already imposed by the lack of hydrology. A lack of information on salmonid use and stream channel/riparian impacts within the watersheds adds to the uncertainty. Water temperatures may also be a factor negatively affecting salmonid productivity within the watersheds, given low flow conditions. The extent to which human activities may exacerbate this condition is unknown. Studies are needed that collect data and analyze the change over time in riparian habitat, wetland habitat, floodplain function, sediment delivery and transport, temperature regimes, and groundwater/surface water interactions.

Information generated by these studies would contribute to making more informed conclusions about the extent to which salmonid productivity is limited beyond natural conditions, by human-induced alterations to stream channels and riparian conditions.

Studies on surface water quality have been conducted in East Foster Creek (WRIA 50), Douglas Creek and tributaries (WRIA 44) and the Sagebrush Flats area (WRIA 44, Upper and Lower Moses Coulee Subwatersheds). These studies have indicated some degree of soil erosion and sedimentation is occurring, lowering water quality within the watersheds and the drainages downstream on to the Columbia River. Erosion problems occur due to fine-grained soils susceptible to erosion, intense rainfall, or sudden snowmelt but the studies were of short duration and are now dated making it impossible to draw any reliable conclusions. It is difficult to identify the cause of soil erosion and sedimentation and draw conclusions between farming practices, on-site conservation practices, and water quality.

Ground water quality was monitored in wells around Mansfield and Douglas Creek. Samples were found high in nitrates and coliform bacteria, relative to drinking water standards. In Mansfield there was no conclusive evidence as to the source of nitrate problem and nitrate concentration fluctuations (Johnson 1974). High nitrates around Douglas Creek according to hydrologist, Allen Isaacson in a Water Quality Report for South Douglas Conservation District in 1989, were due to the high percentage of land that is fertilized and the low flows that do not dilute these levels until lower in the watershed (Isaacson 1989).

A more detailed discussion of known habitat conditions in each subwatershed can be found in the *Habitat Limiting Factors by Subwatershed* chapter of this document. As stated above, the lack of existing baseline data for such basic habitat attributes like instream flows, sedimentation and temperature, and the lack of analysis comparing the change in riparian, wetland, floodplain and upland habitats, limits this report to a reliance almost entirely on the professional expertise of the TAG and landowners as the best available science. As more data is collected and analysis conducted, the assessments of this TAG can be refined and new conclusions may be drawn. More data and analysis can lead to a greater accuracy in assessing the affects of habitat conditions on salmonid spawning and rearing use in the Foster and Moses Coulee Watersheds. Presently, it is the conclusion of the TAG and landowners that although there are human impacts in the Foster and Moses Coulee Watersheds, these impacts have a very limited affect on anadromous salmonid spawning and rearing use in the watersheds. This is mostly a reflection of the natural limitation imposed on the habitat by the arid, shrub steppe ecosystem (TAG 10-30-00; TAG 11-21-00).

Recommendations made by Technical Fish Experts and Landowners

Recommendations made by the technical fish experts and landowners at the October 30, 2000 Salmon Forum were as follows:

- Conduct general presence/absence salmonid surveys on selected streams highlighted by the information provided so far by the TAG (Foster, Moses

Coulee, Sand Canyon, Rock Island, Douglas Creek). Salmonid distribution information is limited and based on existing professional knowledge and surveys in the 1970's, 1980's, and 1990's. Habitat conditions have changed and there is a need to conduct an updated salmonid survey.

- Collect baseline data on known fish bearing streams for the following habitat parameters: fine sediment, temperature, and instream flows. Use commonly accepted survey protocols (i.e. Hankin and Reeves. 2000. Pacific Northwest Region US Forest Service Stream Inventory Handbook, Level I and II).

- Research surface/ground water interactions and investigate the opportunity for augmenting low instream flows.

- Install stream gauges to learn more about the instream flows in WRIA 44 and 50.

- Using historical information gathered from landowners, conduct analyses of changes over time of riparian, floodplain and wetlands acreage and conditions, and uplands vegetation cover types, as they affect watershed hydrology.

- Habitat restoration projects must be directed at the condition(s) causing the habitat degradation (causal mechanisms), not at its symptoms. Structural manipulations of the stream channel (such as boulder or log placements) should not be used unless those causal mechanisms cannot be corrected within a reasonable time. Attempts to restore habitat are likely to fail if structures are placed in the stream channel without addressing those activities that are causing the habitat degradation. To identify causal mechanisms prior to implementing any structural manipulation of the channel, an evaluation of the stream channel hydrology, geology and morphology (hydrogeomorphology) must first be conducted. Habitat restoration projects must be designed to conform to natural channel processes when possible. Potential impacts from habitat restoration projects that do not support natural channel processes must be fully understood prior to implementation. For example, during high flows, rehabilitating structures are likely to blow out and it would be senseless to repair an artificial habitat after every flood event.

Overriding inventory and assessment needs for the Foster and Moses Coulee watersheds include a watershed-wide collection of baseline data. A more detailed list of data gaps is included in the *Data Gaps and Recommendations* chapter.

INTRODUCTION

This report was written pursuant to Engrossed Substitute House Bill (ESHB) 2496 as codified in RCW 75.46, the Salmon Recovery Act, a key piece of the 1998 Legislature's salmon recovery effort. It represents a compilation of information regarding known habitat conditions in the Foster WRIA 50 and the Moses Coulee WRIA 44.

Engrossed Substitute House Bill (ESHB) in part:

- directs the Conservation Commission in consultation with local government and the tribes to invite private, federal, state, tribal and local government personnel with appropriate expertise to act as a technical advisory group (section 090, subsection 1, RCW 75.46);

- directs the technical advisory group to identify limiting factors for salmonids to respond to the limiting factors relating to habitat pursuant to section 070 subsection 2 of this act (section 090, subsection 3, RCW 75.46);

- defines limiting factors as "conditions that limit the ability of habitat to fully sustain populations of salmon." (section 010, subsection 5, RCW 75.46);

- defines salmon as "all members of the family Salmonidae which are capable of self-sustaining, natural production." (section 010, subsection 7, RCW 75.46).

The overall goal of the Conservation Commission's limiting factors project is to identify habitat factors limiting production of salmonids in the State. This report identifies habitat limiting factors pertaining to salmon, steelhead trout and bull trout. It is important to note that the responsibilities given to the Conservation Commission in ESHB 2496 do not constitute a full limiting factors analysis. The hatchery, hydro and harvest segments of identifying limiting factors are being dealt with in other forums.

A comprehensive assessment of habitat factors that are limiting natural salmonid production in the Foster and Moses Coulee watershed could not be developed with the available information. To accomplish this goal baseline data on habitat conditions in all portions of the watershed needs to be available. The assessment of how the habitat-related factors limit the ability of the habitat to fully sustain salmonid populations in the Foster and Moses Coulee watershed could then be correlated to species and life stage. Data needs are fully described in the end of the *Data Gaps and Recommendations* chapter of this report.

The Role of Habitat in a Healthy Population of Natural Spawning Salmon

Washington State anadromous salmonid populations have evolved in their specific habitats during the last 10,000 years (Miller 1965). Water chemistry, flow, and the physical attributes unique to each stream have helped shape the characteristics of each salmonid population. These unique physical attributes resulted in a wide variety of distinct salmonid stocks for each salmonid species throughout the State. Stocks are population units within a species that do not extensively interbreed because returning adults rely on a stream's unique chemical and physical characteristics to guide them to their natal grounds to spawn. This maintains the separation of stocks during reproduction, thus preserving the distinctiveness of each stock.

Salmonid habitat includes physical, chemical and biological components. These components include water quality, water quantity or flows, nutrients, stream and river physical features, riparian zones, upland terrestrial conditions, and ecosystem interactions as they pertain to habitat. Changes in stream flows can alter water quality by affecting temperatures, decreasing the amount of available dissolved oxygen, and concentrating toxic materials. For example, water quality can be reduced by heavy sediment loads which result in increased channel instability and decreased spawner success. The riparian zone interacts with the stream environment, providing nutrients and a food web base, woody debris for habitat and flow control (channel complexity), filtering runoff prior to surface water entry (water quality), and providing shade to aid in water temperature control.

Salmonid habitat requires clean, cool, well-oxygenated water flowing at a natural rate for all stages of freshwater life. Salmonid survival depends upon specific habitat needs for egg incubation, juvenile rearing, migration of juveniles to saltwater, estuary rearing, ocean rearing, adult migration to spawning areas, and spawning. Specific needs vary by species and even by stock.

When adults return to spawn, they not only need adequate flows and water quality, but also unimpeded passage to natal grounds. They need pools with vegetative cover and instream structures such as root wads to provide for resting and shelter from predators. Successful spawning and incubation requires sufficient gravel of the right size for the stock (or population), in addition to the constant need of adequate flows and water quality, all in unison at the necessary location. Also, delayed upstream migration can be critical. After entering freshwater, salmon have a limited time to migrate and spawn, sometimes as little as 2-3 weeks. Delays result in pre-spawn mortalities, or spawning in suboptimal locations.

The eggs need stable gravel that is not choked with sediment. River channel stability is vital at this life history stage. Floods have their greatest impact to salmon populations during incubation, and human activities can worsen these impacts. In an undisturbed system, upland vegetation stores water and shades snowpack slowing the rate of water runoff into the stream. A healthy river has sinuosity with large pieces of wood contributed by an intact, mature riparian zone. The uplands and riparian areas both act to slow the speed of water downstream. Natural systems have access to floodplains where wetlands store floodwater and later discharge this storage back to the river during lower flows. Erosion or sediment produced in a healthy system provides a constant supply of new gravel for spawning and incubation without increasing overall channel instability. A stable incubation environment is essential for salmon, but is a complex function of nearly all habitat components contained within that river ecosystem.

When the young fry emerge from the gravels, some species of salmonids migrate quickly downstream, quickly exiting the basin, while other species search for suitable rearing habitat within side channels and sloughs, tributaries, spring-fed "seep" areas, and stream margins. Quiet water margins and off-channel areas are vital for early juvenile habitat. The presence of woody debris and overhead cover aid in food and nutrient inputs as well as provide protection from predators. As growth continues, the juvenile salmonids (parr) will move away from the quiet shallow areas into deeper, faster water.

During the winter, salmonids require habitat that will sustain growth and protect them from predators and harsh winter conditions. Habitat use is determined by behavior changes associated with declining temperatures in the fall and winter. Behavior changes vary by species and life stage (Bjornn and Reiser 1991). In a study of seasonal habitat use of juvenile chinook salmon and steelhead in the Wenatchee River (Don Chapman Consultants 1989) juveniles were located along the stream margin in boulder zones from October to March. During the day they hid in interstitial spaces among boulders; at night both species stationed on boulders and sand adjacent to their daytime habitat. When water temperatures dropped below 50° F (10° C), juveniles were not observed in the water column during the daytime, but remained in the substrate. Adult steelhead that overwinter in the upper-Columbia region are thought to generally seek refuge in the mainstem Columbia River. Some adults will also seek refuge in deep pools of the mainstem tributaries to the Columbia River (Chuck Peven, personal communication) but may return to the Columbia River if instream water temperatures become too harsh (Larry Brown, personal communication). Bull trout embryos and alevins overwinter in the gravels for more than 200 days (Fraley and Shepard 1989) making their survival closely dependent on relatively stable thermal regimes. Baxter et al. (1999) considered that groundwater-influenced areas within alluvial valley areas in Montana may be important to egg incubation, emergence success, and the survival of juvenile bull trout.

The following spring, smolts begin seaward migration. Flows, food and cover that provide protection from predators are critical. Once again the unique natural flow regime in each river that shaped the population's characteristics through adaptation over the last 10,000 years, plays an important role in the salmonids behavior and survival. In contrast to this, salmonids from the upper-Columbia region must migrate through a river system that has been highly altered by hydroelectric development. Hydropower dams converted the free-flowing Columbia River to a series of reservoirs upstream from the site of Priest Rapids Dam. Subyearling summer chinook salmon produced in upper-Columbia tributaries tend now to spend several weeks in the reservoirs before they arrive at Priest Rapids Dam in August and later. This has substantially increased the mean size of subyearlings at time of passage at Priest Rapids Dam (Chapman et al. 1994a)

Once reaching the estuary, that food-rich environment provides an ideal area for rapid growth. Adequate natural habitat must exist to support the detritus-based food web, such as eelgrass beds, mudflats, and salt marshes. Also, the processes that contribute nutrients and woody debris to these environments must be maintained to provide cover from predators and to sustain the food web. Common disruptions to these habitats include dikes, bulkheads, dredging and filling activities, pollution, and alteration of downstream components such as woody debris and sediment loads.

The distribution, seasonal abundance and migratory behavior of salmon and steelhead, exiting the estuary for the nearshore and offshore ocean environment varies considerably (Groot and Margolis 1991; Chapman et al. 1994b; Chapman et al. 1995a). The movements of chinook at sea are more complicated than those of sockeye and pink salmon. Ocean residence for spring chinook is 2-3 years compared to 3-4 years for summer/fall chinook. First-year chinook remain along the Pacific Northwest continental shelf north to the Gulf of Alaska more than other first-year salmon species (Chapman et al. 1995a). In contrast, distribution of young steelhead differ in time and space from any salmon. Steelhead do not remain along the coastal belt but move directly seaward during their first ocean summer (Chapman et al. 1994b).

In addition to relationships between various salmonid species and their habitats, there are also interactions between the species that have evolved over the last 10,000 years. This relationship is complicated by the introduction of non-native salmonid species (brook trout), the introduction of salmonid hatchery stocks, and planting of hatchery fish. For competition to occur, demand for food or space must be greater than supply and environmental stresses few and predictable (Chapman et al. 1995a). Each species is best adapted to only a subset of all the conditions within a stream with the total habitat used by a species divided into preferred and less preferred areas, the latter being areas used by a species but affording less than optimal conditions (Hearn 1988). In this environment, survival of one species might be negatively impacted by the presence of another species, especially for less competitive species in less preferred habitat areas (Mullan et al. 1992).

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WATERSHED CHARACTERISTICS AND CONDITIONS

Location

The Foster WRIA 50 and Moses Coulee WRIA 44 are located in North Central Washington close to the geographic center of Washington State (Figure 1). WRIA 50 and WRIA 44 lie in the "Big Bend" area of the Columbia River in the shelter of the Cascade Mountains to their West (Douglas County 1995). WRIA 50 lies the north of WRIA 44.

Foster WRIA 50 encompasses northern Douglas County and a portion of the Colville Indian Reservation in southern Okanogan County. The Foster WRIA 50 covers approximately 699 square miles (447,140 acres). The primary drainage of WRIA 50 is the Foster Creek Watershed draining an approximate 334 square mile catchment (213,639 acres) (Acres calculated by U.S Department of Agriculture Soil Conservation Service, Watersheds Map 1977).

The majority of Moses Coulee WRIA 44 is located in Douglas County with the remaining area in Grant County. The Moses Coulee WRIA 44 covers approximate 1,213 square miles (776,222 acres). The primary drainage of WRIA 44 is the Moses Coulee draining an approximate 206 square mile catchment (131,852 acres) (Acres calculated by U.S Department of Agriculture Soil Conservation Service, Watersheds Map 1977).

The primary drainage basins that handle surface water runoff, Foster Creek and the Moses Coulee, both deposit directly into the Columbia River (Douglas County 1995). The Foster Creek drainage basin outlets at Columbia River Mile (RM) 554.6 near the Chief Joseph Dam at Bridgeport. The Moses Coulee outlets at Columbia River Mile (RM) 447.9 seven miles south of the city of Rock Island (Douglas County 1995; WDFW Stream Catalogue)

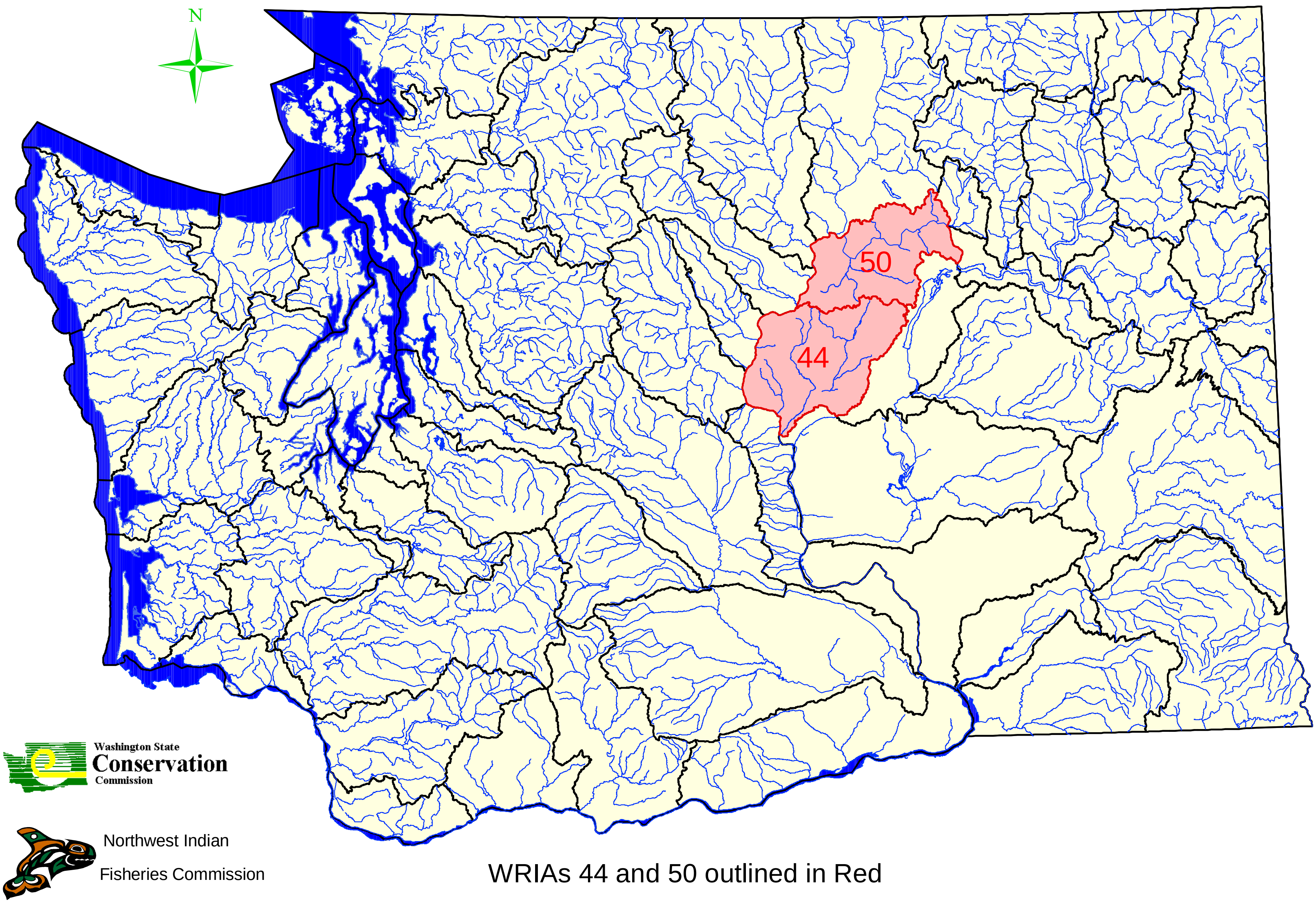
WRIA 50, north of the Columbia River lies outside of Douglas County within the Colville Indian Reservation and is not addressed in this report.

Topography

The majority of WRIA 50 and WRIA 44 is rolling plateau, underlain by basalt, interspersed by intermittent drainages. Elevations range from approximately 800 feet at the Columbia River to 4,100 feet at Badger Mountain. Average elevations range between 2,000 and 3,000 feet mean sea level. Higher terrain is in the southwest at Badger Mountain and northeast in the Okanogan Highlands. Lower elevations include the Moses Coulee and areas along the Columbia River (Johnson 1974).

WRIA 50 and WRIA 44 are part of a larger drainage, the Columbia River Watershed. The Columbia River cuts a deep gorge westward through WRIA 50 and then curves southward marking the western boundary of WRIA 50 and WRIA 44. In most places along the river there are a series of nearly level to gently sloping terraces. Long, steep slopes lead from these terraces to the broad upland plateau.

Figure 1 - Location of WRIAs 50 and 44 in Washington State



WRIAs 44 and 50 outlined in Red

Moses Coulee, a dominating geologic structure, in WRIA 44 is a deep, wide flat-bottomed valley between Badger Mountain and Beezley Hills. This coulee is a former channel of the Columbia River, formed when the river was diverted from its present course by glacial dams during the late Pleistocene era (10,000 years ago). The coulee gradually descends as it extends southwesterly through WRIA 44 to its end on the bank of the Columbia River. Steep side slopes rise about 600 feet from the valley floor before leveling off in the upper plateau. The valley bottom is a nearly level floodplain ranging from one-half to three-fourths of a mile wide (KCM 1995; Beieler 1981).

Climate

The climate of WRIA 50 and WRIA 44 is influenced by elevation, topography, distance and direction from the ocean, prevailing westerly winds and the position and intensity of the high and low pressure centers in the western Pacific Ocean (Thompson and Ressler 1988). The mountains partly shield the area from strong Arctic winds resulting in cold but not severe winters. In summer, Pacific Ocean winds are partly blocked; days are hot, but nights are fairly cool (Beieler 1981).

Temperature ranges can vary noticeably between the lowland river corridor areas and the plateau. Waterville records give good data for the upland plateau part of the WRIAs with an average winter temperature of 26 ºF. Wenatchee records give good data for the lower, irrigated orchard land part of the WRIAs with an average winter temperature at 32 ºF. Winter monthly maxima average in the 30-40 degree range, while average monthly minima commonly fall into the 10-20 degree range. Summer months bring an average temperature of 65 ºF in Waterville and 71 ºF in Wenatchee. During the warmest summer months, afternoon maximum temperatures normally fall into the 85-95 ºF range. Temperatures above 100 ºF usually occur only 2-5 days per year (Beieler 1981; Thompson and Ressler 1988).

Precipitation, except in mountainous areas, is scant in summer, but in many places adequate during the cooler parts of the year for nonirrigated small grains or range plants. Snowpack accumulation at high elevations supplies irrigation water for intensive agriculture in parts of the lowland. Average precipitation ranges from 8 to 12 inches, 9 inches in Wenatchee and 11 inches in Waterville depending on the elevation and topography of a specific area. The heaviest precipitation occurs during the winter months as snowfall. Annual snowfall varies from 10 to 30 inches throughout the area. Of the total, an annual precipitation of approximately 16% or 1.81 inches is received during the summer months of June, July and August. This low summer precipitation often causes streamflow to draw on groundwater sources and during the summer streamflow ceases altogether in most of the area’s creeks (Beieler 1981; Douglas County 1995; Johnson 1974).

Subfreezing temperatures are experienced about 140 to 160 days per year. Frost penetration of the soil varies from one winter to the next depending upon soil type, vegetation cover, snow cover, and temperature. Average depth of the frost is 10-20 inches. Early snowfall will insulate the ground and reduce the depth of freezing to only a few inches, whereas lack of early snow can result in freezing depths approaching 30 inches. Flooding and erosion problems often result when the underlying soil is frozen and heavy runoff from rain or snowmelt occurs (Beieler 1981; Douglas County 1995; Johnson 1974).

Prevailing wind direction and speed varies according to topographic situation and season. Fifty mile per hour winds can be expected an average of once in two years, and seventy mile per hour winds once in twenty-five years. High winds occur with greater frequency on exposed ridges and the upland surface of the watershed than on the floodplains (Thompson and Ressler 1988).

Hydrology

WRIA 44 and 50 are unique in their hydrology. Most steams are intermittent, feed by spring runoff or a spring system and shaped by high flow events. Some years there are perennial flows, but this hydraulic continuity is unlikely year around (TAG 10-30-00).

Storms of extreme intensity and short duration occur in the watersheds causing high flood events. Flood events are causes by two distinct climatological patterns: summer thunderstorms or a warm rain-on-snow storm event. Thunderstorms occur primarily during the summer months and normally have high rainfall intensities over relatively small areas (KCM 1995; Johnson 1974). Major thunderstorms typically have peak rainfall intensities as high as 0.5 inches in 15 minutes, 1.25 inches in 1 hour, and 2.0 inches in 90 minutes (KCM 1995). Rain-on-snow events occur in the late winter or early spring, usually with smaller amounts of precipitation; however, with the ground frozen and infiltration prevented, the melting snow combined with rainfall can create a large runoff event. Flooding problems are not widespread, but are occasionally severe on alluvial fans and localized flood plains, which are subject to flash floods. (KCM 1995; Johnson 1974). Major floods have occurred about every 10 years, although smaller storms causing localized damage are more frequent. The largest floods in recent history occurred in 1972 and 1989. Several smaller events occurred in 1957, 1973, 1975, 1976, 1991, and 1993 (KCM 1995).

The existing stream corridors have been shaped and continue to be reshaped by high flood events. Water moves fast and transports sediment. High flows have been recorded on Douglas Creek up to 1000 cubic feet per second. Flows during the rest of the year can be nonexistent (TAG 10-30-00).

The Columbia River drains both WRIA 44 and 50. Several tributaries to the Columbia River in WRIA 44 and 50 have sizable drainage areas. These include Foster Creek, Corbaley Canyon (locally know as Pine Canyon), Sand Canyon, Rock Island Creek, and the Moses Coulee that drains directly into the Columbia (KCM 1995; Johnson, 1974; TAG 10-30-00).

With the exception of the Columbia River, streamflow records in Douglas County are minimal. The U.S. Geological Survey (USGS) has collected annual peak flow measurements for several of the major streams in the County, but the records are short and dated (KCM 1995). According to the Douglas County Water Pollution Control and

Abatement Plan Steam flow records in WRIA 44 and 50 are minimal meaning short, fragmented and dated. The only year-round flow measurements are taken on the Columbia (Johnson 1974). Monitoring stations in Douglas County measuring annual peak flows can be viewed at the USGS web site http://waterdata.usgs.gov.

Major natural lakes in WRIA 44 and WRIA 50 include Jameson (332 surface area in acres), Atkins (149 surface area in acres), Grimes (124 surface area in acres), and Goose Lake (216 surface area in acres). Several smaller lakes (less than 100 acres) and seasonal "potholes" are scattered throughout the area. As the lakes are sustained by groundwater they can be indirectly related to water quantity in the streams. Man-made reservoirs are limited to impoundments behind Columbia River dams including Rock Island, Entiat, Pateros and Rufus Woods Lakes (KCM 1995; Johnson 1974).

Geology and Ground Water Movement

Geology

The geology of WRIA 44 and WRIA 50 can best be described by a sequence of extruding lava, glaciation, and then flooding.

WRIA 44 and a portion of WRIA 50 south of the Columbia River are part of the extensive Columbia River Plateau which was formed by the extrusion of lava during the Eocene, Miocene and Pliocene epochs, approximately 12, 30 and 60 million years ago respectively. After basalt was extruded, the region was warped into broad basins in which several sub-basins were formed by locally intense folding by faulting. In these sub-basins, deposits of clay, silt, sand and gravel accumulated during the Pleistocene or glacial epoch approximately one million years ago (KCM 1995).

Eruptions were not from a single vent but from very long cracks or fissures extending miles in length. An individual eruption was probably fed by many fissures erupting simultaneously. The thick lava sequence consisted of an undetermined number of flows, which in places, are separated by sedimentary interbeds. Varying thickness of sediments overlie the basalt in nearly all locations, with basalt generally more deeply buried beneath the coulees than beneath the uplands (KCM 1995).

Lava flows were generally restricted to areas south of the present location of the Columbia River; however, thinner layers of basalt extend north of the Columbia River. North of the river, the basalt becomes progressively thinner to where granite rock outcrops at the land surface. In this region (northern part of WRIA 50) faulting and folding has shaped mountainous terrain into what is known as the Okanogan Highlands physiographic province (Johnson 1974).

Approximately, 100,000 years ago glaciers began to move southward down the major river valleys of the Okanogan, San Poil, Columbia, Colville, Pend Oreille, and Priest River Valleys and the Purcell Trench. Glaciers moving south down the valleys of Okanogan and Columbia Rivers encountered the high basaltic rim of the plateau along the east-west segment of the Columbia River-Spokane axis. .

This rim was a partial barrier to the ice, but glaciers proceeded to enter from the Northwestern side of Douglas County- there the Okanogan Lobe spread almost 30 miles south across the Waterville Plateau. Okanogan Lobe fanned out from the plateau rim near Bridgeport and flowed southeast toward Coulee City, south toward Mansfield, and southwest toward the foot of the Cascades at Chelan.

The surface of the Waterville Plateau preserves many classic glacial features. The veneer of glacial deposits is generally thin, and the basalt bedrock is exposed in many places. Glacial grooves and striations are evident on some rock surfaces. The glacier carried granite derived sediment from Okanogan Valley, and basalt peeled from the north rim of the plateau as it was overrun by the ice where deposited. Light colored glacial erratics from the Okanogan scattered on the plateau surface as well as great blocks of basaltic bedrock peeled from the plateau rim. Some of these blocks are as big as a house. The Okanogan Lobe of ice left a large deposit of glacial till called the "Withrow moraine" to mark its southern margin. This broad ridge several miles wide and full of irregular hills and depressions extends from Chelan southeast to the area just north of Coulee City.

Moses Coulee was formed by the Columbia River in relatively recent Pleistocene time (10,000 years ago) when the river, diverted by a large ice lobe near the present day Grand Coulee Dam, cut through the thick basalt formations of the Columbia River Plateau. The basalt layers vary in thickness from 6,000 to 10,000 feet and date primarily from the Miocene epoch (30 million years ago). Erosion and formation of Moses Coulee and other river meltwater channels in the region (including the Grand Coulee) was augmented by enormous floods from Lake Missoula, a glacially dammed mountain lake east of Spokane that was alternately blocked and opened by glacial fluctuations. The Spokane Floods left giant current ripples and giant gravel bars in a great sweeping switchback on the west side of the Moses Coulee. The floodwaters ripped off the cover of loess along the main channels and cut into the basalt bedrock. The Spokane floods, as they are commonly termed, were responsible for many of the present-day landscape formations in the Columbia River basin. The flat bottomed coulees are now filled with several hundred feet of glacial and river deposits (KCM 1995).

Therefore, the Columbia Plateau glaciation includes not only the effects produced directly by the passage of ice over the ground but also all the modification brought by glacial meltwater and glacially diverted rivers far beyond the terminus of the ice (KCM 1995; McKee 1972; USGS 1974).

<u>Ground Water</u>

A good understanding of an area's geologic characteristics is necessary to understand the factors influencing surface and groundwater movement and quality. Geological formations control groundwater yield and the depths at which the water can be obtained (Johnson 1974).

Interflow zones within the basalt bedrock and course grain glacio-fluvial deposits throughout the Moses-Coulee and Foster Creek Basins constitute important sources of groundwater. Where structures in the basalt separate sub-basins, they act as barriers to groundwater flow between basins. Underlying the sedimentary deposits, at various depths, are stratas of basalt, ranging from approximately 20 to 100-feet thick, over most of the region. Centers of individual flows are generally dense and store very little groundwater. Tops of flows are usually permeable due to their highly fractured or vesicular nature. The basal part of the flows is permeable where pillow structures or gas pockets were formed or where openings were left between flows. Where a lava flow with pillows (or gas pockets) at its base immediately overlies a flow whose top is fractured, the resulting interface contains large quantities of groundwater. Good yields are obtained from properly-constructed wells.

Natural recharge to the aquifer units in the higher plateau area is thought to be very low and due to direct precipitation and/ or seepage from streams. Much of the groundwater was apparently introduced to storage during the glacial period. Groundwater storage volumes available are rough estimates and will have to be confirmed by additional measurement and analysis (Johnson 1974).

Soils

Current Soil Survey

Findings for this report are based on the 1981 Soil Survey of Douglas County, Washington. The survey presents a general soil map representing broad areas with distinctive soil pattern, relief, and drainage. A new soil survey is underway to more specifically address soils in Douglas County. According to Thompson and Ressler in an East Foster Creek watershed report investigating problems of soil erosion, water quality and wildlife habitat improvement, "The present soil survey of the area (East Foster Creek) has proven inadequate to the needs of the kind of integrated management plan that needs to put into effect. A more detailed soil survey is necessary in order to understand and effectively relate the hydrology to potentials for supporting the required revegetation necessary to reduce soil erosion, and improve water quality and wildlife habitats" (Thompson and Ressler 1988). The Sagebrush Flats Watershed Erosion Control Project was conducted to provide data on existing levels of water quality and soil erosion, including an inventory of cropland to determine the amount and rate of soil loss and map critical erosion areas. "Not only did the inventory show the need for Best Management Practices, but it also indicated a lack of accurate information about the types of soils in the watershed" (Herring 1985).

Soil Description

The Soil Survey divides Douglas County into seven broad soil units. The most dominate soils are of the Touhey-Heytou association, a glacial till, and the Renslow-Zen association, a loess or fine wind blown soil. Touhey loam dominates 276,417 acres, 23.7% of the county and Bakeoven-Touhey dominates 119,417 acres, 10.7% of Douglas County. The Renslow-Zen association dominates 157,901 acres, 13.5% of the county. Another important distinct soil type is of the Pogue-Quincy-Xerorthents association, a sandy river soil dominating the Columbia River shoreline (Beieler 1981).

The basalt plateau of WRIA 50 and WRIA 44 is dominated by glacial till and extremely fine wind-blown soils. Soils found on the plateaus and upland areas are usually a silt-loam type, best adapted for dryland farming. Generally speaking, WRIA 50 is dominated by glacial till, while WRIA 44 is dominated by loess, wind blown sand and silts (E. Benson, NRCS). WRIA 50 is dominated by Touhey-Heytou soils association, a very deep well drained, nearly level to moderately steep soils; on broad uplands and basalt plateaus. WRIA 44 is dominated by Renslow-Zen association, a very deep and moderately deep, well drained, nearly level to moderately steep soils; on broad basalt plateaus (Beieler 1981). The Douglas County Water Pollution and Abatement Plan states the shallow silt-loam in the southern part of WRIA 44 and 50 have generally poor drainage characteristics. The sand-loam and deeper silt-loam soils in the northern part of WRIA 44 and 50 have better drainage characteristics (Johnson 1974).

In general, soils along the Columbia River are predominately well-drained sands and gravels which, when combined with irrigation, provide an excellent medium for orchards. (KCM 1995). These river soils are of the Pogue-Quincy-Xerorthents association, a very steep, very deep, somewhat excessively drained, nearly level to very steep soils; on terraces and terrace escarpments (Beieler 1981).

Erosion and Sedimentation

The northern part of Douglas County (WRIA 50 and northern WRIA 44) is mostly glacial till. The southern part of Douglas County (WRIA 44) is loess, wind blown sand and silts. Both soil types are equally susceptible to land management practices that exacerbate conditions that contribute to soil erosion (E. Benson, NRCS, pers. comm., 2000). Shallow, fine textured soils in WRIA 44 and 50 are easily eroded and cause sediment pollution in streams (Johnson 1974). Wind and water erosion is severe in both watersheds, but heaviest on the Waterville-Mansfield Plateau. Heavy sediment yields are generated during periods of snowmelt, during rain-on-snow events when the underlying ground is frozen, or during high intensity rainstorms in the summer months (Johnson 1974).

In WRIA 44 and 50, cultivated lands are left without a cover crop for a season (fallow) that allows soil to regain moisture and to eliminate weeds or pests. When previously cultivated soils are left without a vegetative ground cover, especially the very fine, sandy soils that are common in WRIA 50, surface water runoff can result in delivery of topsoil (sediment) to nearby stream systems. The delivery of sediment-laden water carrying silt, fertilizer, pesticides and herbicides can pollute water supplies and threaten salmonid populations (Thompson and Ressler 1988). The East Foster Creek Watershed Hydrology and Sedimentology Study done by Munson Engineers in 1989 documents most soil grains transported through intermittent stream channels eventually travel through East Foster Creek and on to the Columbia River. However a few intermittent streams pass through small ponds and reservoirs where the flow slows and the soil grains settle, thereby depositing part or all the sediment load (Munson 1989).

Adverse water quality affects may result from chemical applications on farmland. Agricultural pollutants (insecticides and pesticides, etc.) attached to eroded soil particles are often carried long distances in watercourses (Johnson 1974). Where pesticides and fertilizers are concentrated by runoff into water bodies, the resulting rise in nutrient concentration may cause algal blooms. Ground water also can become contaminated as chemicals filter down to the storage aquifer (Johnson 1974). Algal blooms around Jameson Lake, potamogeton (pondweed) growths in the Columbia River, and rising nitrate levels in wells around Mansfield are partially attributed to agricultural chemicals (Johnson 1974).

The delivery of untreated surface water runoff from livestock feedlots into surface waters can also degrade water quality and negatively affect salmonids. Although it is estimated that under favorable conditions, nearly all cattle waste production can be removed by soil filtering and natural decomposition, untreated feedlot waste runoff can result in high concentrations of bacterial and organic pollutants in streams (Johnson 1974). Animals concentrated in feedlots along streams can also lead to accelerated soil erosion when the ground is compacted, vegetative cover is eliminated, and surface water runoff from the feedlot is not properly managed. These conditions speed the delivery of runoff into receiving waters, increasing instream water velocities instead of allowing for water to filter into the soil where it can be slowly released into surface waters or directed into an aquifer. Snowmelt and precipitation runoff over compacted unvegetated ground, also contributes to soil erosion by concentrating overland flows that can erode vulnerable soils. Frequency of waste discharge and the number of animals or total wastes involved in the discharges are the primary criteria for use in categorizing animal waste problems. Frequency of discharge is highly dependent on climate and ranching operations (Johnson 1974). Most ranchers in WRIA 44 and 50 do not keep all their cattle year around in one location. Cattle are often transported to winter and summer grazing areas outside the basin. Under this type of operation, intermittent pollution can occur where grazing cattle congregate in a small area to feed. Some of these feeding areas are located near surface waters where pollution can occur (Johnson 1974).

Vegetation

The natural vegetation of the Foster Creek WRIA 50 and Moses Coulee WRIA 44 varies in response to temperature, moisture availability, and soil characteristics. Native vegetation in open range areas is typical of semi-arid climate regions of the Columbia Basin including bunchgrass, sagebrush, and widely scattered bitterbrush (KCM 1995).

Shrub-steppe

Shrub-steppe (sagebrush/ grass) is the most widespread vegetative cover in Douglas County found largely on the upland areas and in the breaks. It is dominated by woody perennial shrubs such as three-tip sage (*Artemisia tripartita*), big sage (*A. tridentata*), bitterbrush (*Purshia tridentata*), and rabbitbrush (*Chrysothamnus nauseosus*) along with perennial and annual grasses such as bluebunch wheatgrass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*), and Sandberg's blue-grass (*Poa sandbergii*). Shrub steppe lands have been invaded by introduced annuals (cheatgrass, mustards, and other undesirable species) as a result of past management practices, uncontrolled grazing, and importation of species on wheels and chassis of vehicles (Thomson and Ressler 1988).

Biological soil crust is an integral component of shrub steppe creating a rough crust on the soil surface. Biological soil crusts also know as "cryptobiotic crust", "microbiotic crusts" or "cryptobiotic crusts" are a fragile microfloral communities composed of blue-green algae, bacteria, fungi, mosses, and lichens. Many biologist think these crust communities may play an important role in dry regions by stabilizing soils from wind and water erosion, contributing to soil productivity, influencing nutrient levels, retaining moisture, altering soil temperature, and aiding seedling establishment (Paige and Ritter 1999).

Forested Lands

Forested areas are limited by the arid climate of Douglas County, to about 8,000 acres, mostly on the north slope of Badger Mountain. Forests consist of scattered stands of Douglas-fir (*Pseudotsuga douglasii*) and ponderosa pine (*Pinus ponderosa*) on Badger Mountain and in Corbaley Canyon a (WRIA 44; Beieler 1981).

Riparian Areas

Along natural drainage corridors and the Columbia River where soil and moisture conditions support the growth of trees and shrubs. Native riparian vegetation can be characterized by a mosaic of shrubby thickets with patches of deciduous trees and grass/forb-dominated plant communities. A diversity of shrub and deciduous tree species occurred historically and still occur in some places, and they include snowberry (*Symphoricarpus albus*), wild rose (*Rosa spp*.), black hawthorn (*Crataegus douglasii*), hackberry *(Celtis reticulata)*, cow-parsnip (*Heracleum lanatum*), common choke cherry (*Prunus virginiana*), bittercherry (*Prunus emarginata*), mock orange (*Philadelpus lewisii*), red osier dogwood (*Cornus stolonifera*), water birch (*Betula occidentalis*), willow (*Salix spp*.), black cottonwood (*Poplulus trichocarpa*), and quaking aspen (*Populus tremuloides*). Succulent herbs of the ground layer include sticky geranium, northern bedstraw, fescue, waterleaf, and bracken fern. Conifer trees, including ponderosa pine and Douglas-fir, are widely scattered in eastern Washington at areas of elevation receiving sufficient rainfall and were more likely more common historically than at present (Knutson and Neaf 1997).

Russian olive *(Elaeagnus angustifolia)* and black locust *(Robinia pseudoacacia)* can be found in these habitats, introduced, non-native species, now naturalized but originally planted by settlers and natural resource managers for shade trees and wildlife cover. Reed canary grass (*Phalaris arundinacea*) is sometimes found in riparian areas, an invasive grass species that has replaced native riparian grasses.

Small, intermittent streams and draws may naturally have little or no characteristic riparian vegetation. Instead, they consist of largely upland plant species, including big sagebrush, bitterbrush, rabbitbrush, and spiny hopsage. The presence of woody and herbaceous vegetation assists in moderating stream temperature, sedimentation, water quality and quantity, and debris flows downstream ((Knutson and Neaf.1997).

Most natural drainage corridors, such as East Foster, currently consist of small copses and short galleries along the courses of both perennial and intermittent streams. Typical species are waterbirch (*Betula fontinalis*), aspen (*Populus tremuloides*), hawthorn (*Crataegus douglasii*), willows (*Salix sop*.), and wild roses (*Rosa sop*.) (Thomson and Ressler 1998). Along the Columbia River, high river water levels, groundwater, and irrigation overflow provide moisture levels sufficient to foster a dense, lush shrub-grass understory and stands of cottonwoods (KCM 1995).

Wetlands

The National Wetland Inventory (NWI) provides the best source of information regarding wetlands classes and acreage for WRIA 44 and 50. The NWI maps were created by the U. S. Fish and Wildlife Service, using stereoscopic analysis of high altitude infrared photos. This method was used to produce maps that are an excellent resource, but come with the disclaimer that they are not meant to be 100% accurate. Aerial photo analysis will most commonly fail to detect forested wetlands and some seasonal wetlands, and the maps will not show changes to the landscape that have occurred after mapping. Artificially created farm ponds are not separated from naturally occurring wetlands on these maps. Nevertheless, in the absence of a detailed on-the-ground wetland inventory, the NWI provides data useful at the watershed level (Katherine March WDFW 2001).
In WRIA 50, the NWI shows over twenty thousand acres of wetlands over 578, 608 acres in this watershed, or about 3.5% of the landscape. Most of these are lacustrine and palustrine wetlands, with only 6.85 acres mapped as riverine. The high number of acres mapped as lacustrine, open water, is likely due to including the large Columbia River pools in the analysis. The lacustrine wetlands are systems over 20 acres (Cowardin 1979), situated in a topographic depression or a dammed river channel, and usually lacking trees, shrubs, and persistent emergents. The palustrine systems, which are more familiarly known as "marshes, bogs, swamps, and ponds" (Cowardin 1979) are less than two meters deep, less than 20 acres, and have more functional diversity than lacustrine systems. Important functions for fish in these systems include: removal of potential pollutants such as sediment, nitrogen, phosphorous, metals, toxic organic compounds; reducing downstream erosion and flooding; recharging groundwater and maintenance of base flows in streams; and food web support. Riverine systems include all wetlands and deepwater habitats contained within a channel, except those dominated by trees, shrubs, persistent emergents, mosses or lichens (Katherine March WDFW 2001).

In WRIA 44, the NWI shows 8,857 acres of wetlands over 730,010 acres, or about 1.21% of the landscape. This watershed also has a large amount of open water lacustrine mapping (6,876 acres), which includes Columbia River impoundments. With most of the wetlands classified as lacustrine and palustrine, and only 35 acres riverine, this WRIA has a distribution similar to WRIA 50. Basic wetland functions are also similar, but functional levels will vary on a site-by-site basis(Katherine March WDFW 2001).

In summary, the NWI data show that wetlands are a small percentage of the landscape. Although, according to the Cowardin (1979) classifications, and from what we know of fish distribution in Douglas and Foster Creeks, most of the non lacustrine wetlands are not habitat for bull trout or anadromous salmonids. Functions which indirectly effect these fish, such as base flow maintenance, pollutant removal, erosion and flooding control, and food web support are left to these small areas in large watersheds. There are no comprehensive studies in these watersheds showing wetland acreage or functions lost over time from natural and human causes. A detailed wetland inventory, including functional analysis, would help to identify areas for restoration, enhancement, and protection for fish (Katherine March WDFW 2001).

Conservation Reserve Program (CRP)

Cultivated fields in CRP in WRIA 44 and 50 have been seeded with Crested wheatgrass (introduced) and native grasses as well as some non-native grasses utilized because of shortages of seed from native species. In many fields a few varieties of forbs that do not threaten to become weeds are mixed with the grasses (Thomson and Ressler 1988). 33% of total cropland acres in Douglas County are enrolled in the Conservation Reserve Program. As of January 18, 2001, a total of 186,144.6 acres have been enrolled in the program with 561,442.8 acres remaining in cultivation. In Douglas County the program has reached maximum allowable enrollment with only limited acreage still eligible for the continuos CRP sign-up. CRP sign-up is distributed evenly throughout WRIA 44 and 50 (Sherry Ramen, Farm Service Agency, pers. comm., 2001). There has been a shift in the purpose of Conservation Reserve Program from primarily erosion control to wildlife habitat protection (Mark Bareither, NRCS, pers. Comm., 2001).

Agriculture and Urbanization

Human activities have resulted in a change in many plant communities. Agricultural land use constitutes 48 percent of the County area, with most of this land in dryland wheat farms and only a small fraction (approximately 4 percent of total cropland) under irrigation. Urban, suburban, orchard, and other irrigated areas consist of non-native orchard fruit trees, ornamental trees and brush, grass and other urban landscaping (KCM 1995).

Paige and Ritter, in *Birds in a Sagebrush Sea: Managing Sagebrush Habitats for Bird Communities* (1999), state that sagebrush communities have suffered severe degradation and loss. The ecology, natural disturbance patterns, and vegetation communities have been altered by agricultural conversion, invasion of non-native plants, extensive grazing, development, sagebrush eradication programs, and changes in fire regimes. Within the Columbia River Basin, for example, sagebrush and bunchgrass cover types experienced greater losses than any other habitat and it is predicted it will probably continue to decline given the cumulative impacts of present land uses (Paige and Ritter 1999).

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HISTORIC AND CURRENT LAND USE OF THE WATERSHEDS

When settlers arrived in Eastern Washington in the mid-nineteenth century, they encountered an arid shrub-steppe landscape that seemed inhospitable to agriculture. They used the dry uplands for grazing cattle, sheep and horses and limited their settlement to the bottomlands along tree-lined creeks and parts of the moist Palouse region in Southeast (Washington Dept. of Natural Resources 1998).

Before long, however, some determined farmers discovered the deep-soil uplands were suitable for growing wheat, and the shrub-steppe landscape was plowed to make way for crops. Farming began in the 1870's and most of the county was settled in the 1880's. Plateau areas were settled in the late 1800's with dry land grain crops and livestock grazing. By 1890, irrigation systems along the Columbia River turned 48,000 acres of dry shrub-steppe land to cropland particularly in the Wenatchee Valley (Beieler 1981). The first big canal was built in 1906, Highline Canal to Wenatchee.

By 1890, largely due to the Homestead Act of 1862 and the land grants associated with the Northern Pacific railroad, nearly all the land that could be not planted in crops was grazed. Only small fragments of sagebrush-bunchgrass habitat remained (Washington Dept. of Natural Resources 1998).

Shrub-steppe once covered most dryland areas of eastern Washington, extending from below the forests of the Cascade slope to the prairies of the Palouse. At one time, eastern Washington supported nearly 10.5 million acres of shrub-steppe ecosystems. Today, livestock grazing is the primary land use in the shrub-steppe, although more than half of the original shrub-steppe habitat in the Columbia Basin has been converted to crops.

Alteration of natural fire patterns, fragmentation, livestock grazing, and the addition of hundreds of non-native plant species have changed the character of the shrub-steppe habitat. Prior to Euro-American settlement of the area, fires burned through the shrub-steppe every 30 to 60 years. The vegetation adapted to these periodic fires, leading to additional changes in the type and range of vegetation (Washington Dept. of Natural Resources 1998).

According to the Washington Dept. of Natural Resources, year-round livestock grazing results in a vastly altered landscape. In many places, there are more shrubs because livestock do not eat them, and there are fewer bunchgrasses because they are either eaten or trampled. The hooves of livestock have frayed the cryptobiotic crust that covers the soil. This moss and lichen crust helps prevent soil erosion, contributes to nutrients in the soil, and acts as a protective cover to keep noxious weeds from taking over. The lack of this crust of mosses and lichens disrupts the ecosystem's nutrient cycle and can encourage the proliferation of non-native species, such as cheatgrass (WA Dept. of Natural Resources 1998).

In Sagebrush Flats Watershed before the area was settled most of the watershed supported a cover of native bunchgrasses (Herring 1985). Settlement brought about land use that has resulted in deterioration of much of the watershed. The better soils were plowed first and have been growing wheat continuously under the summer-fallow cropping system for 65-90 years. During the two world wars, and more recently, soils on ground less suited for cropland were also broken and planted to wheat. Most of this land is still under cultivation (Washington Dept. of Natural Resources 1998).

Current Land Use

The predominant land use in WRIA 44 and WRIA 50 is agriculture in the form of dryland grain crop (some CRP), rangeland livestock grazing and irrigated orchard farming. Orchard activities occur along the Columbia River corridor and to some extent in the Moses Coulee. The remainder of the WRIAs on the plateau is where the majority of the grain crop and livestock production takes place. The current agriculture trend is fewer farms but more acreage. The 1992 Census on Agriculture reported a total of 918,033 acres of farm land; 192,782 acres of wheat harvested, 17,307 acres irrigated, 110,259acres in CRP (Douglas County 1995). There are a total of 1,165,184 acres in Douglas County.

Dryland Agriculture

Dryland crop farming takes up a large part of County's land area, particularly on the plateau. The predominant crop because of soil types and climate is winter wheat grown in fallow rotation. Every other year the ground sits idle in order to increase moisture and mineral nutrient content of the soil. Consequently the average dry land farm size in the county is higher when comparing other wheat-growing counties in the state. There is a noticeable change in production from year to year depending on precipitation.

Rangeland

Rangeland activity is primarily beef cattle production consisting of cow/calf operations, with calves being born in early spring and weaned in Oct and Nov. Because of soil types and climate, a portion of the land on the plateau is not suitable for dry land crop production, but it does provide area for rangeland grazing. The largest concentrations of these areas are typically located at the fringes of the plateau, immediately adjacent to basalt breaks.

Irrigated Agriculture

Along portions of the Columbia River corridor orchard activities are the predominant agricultural uses because of sandy well-drained soils; long warm growing seasons and the availability of irrigation water. There is some irrigated farming in the Moses Coulee including orchard and alfalfa.

Conservation Reserve Program (CRP)

The Conservation Reserve Program allows farmers to enroll some of their ground into a 10-year plan of maintaining cover crop, as opposed to typical winter wheat/ fallow rotation that involves harvesting and replanting. This is a multiple use program designed to conserve soil and water and to provide wildlife habitat. During the very dry late 1920's most of the dryland wheat farms sustained moderate to severe wind erosion. By 1930's this erosion had been reduced, largely as a result of more rainfall and better methods of cultivation (Beieler 1981). The government pays a certain dollar amount per acre to the farmer to keep that ground out of production, but maintained with an adequate cover crop and controlled for noxious weeds. Typical cover crops are crested wheat, tall wheat, sherman big blue, or rye grasses or alfalfa. 68% of the land in the CRP program is located in WRIA 50 because of soil types that are prone to wind erosion and are generally less productive than those in the WRIA 44, generally speaking.

Hydroelectric Power

In the 1930s thorough the1950, Federal Bureau of Reclamation projects constructed dams and irrigation systems throughout the semiarid land (Washington Dept. of Natural Resources 1998). Four large hydroelectric dams; Chief Joseph, Wells, Rocky Reach, and Rock Island; are located on the Columbia River.

Urban Areas

There are five incorporated communities and a portion of the town of Coulee Dam in the WRIA 44 and 50. Along the Columbia River in the lowland there is Bridgeport, East Wenatchee, and Rock Island. On the plateau are the two oldest communities, Mansfield and Waterville. In addition there are historic settlement areas of Withrow, Douglas, Orondo, and the Palisades (Douglas County 1995).

Rural portions of the county have experienced some residential and recreational growth. Increase in more up-scale recreational activities such as golf courses that include residential units as part of the overall development primarily around the Columbia River corridor offering water related recreational activities and spectacular views. Because of this diversification into recreational/ tourist industry, the county's economic base has become somewhat more diversified, reliable and stable as well as incidence of incompatible uses have arose. Douglas county history has been intricately tied to a diverse range of agricultural activities and it is likely that the agriculture industry will continue to be a primary mover and shaker in Douglas County future. However, there are some overall downward trends in the agriculture industry (Douglas County 1995).

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FISH DISTRIBUTION AND STATUS

Detailed salmonid studies have not been conducted in the Foster and Moses Coulee Watersheds. Although salmonid stock inventories (WDFW SaSI 1998; WDFW SASSI 1993) have been conducted throughout the state, WRIA 44 & 50 were not included or survey efforts were extremely limited. There are varying and contradicting opinions among fisheries biologists and landowners about known, presumed, and historic/ potential fish use in the Columbia River tributaries of WRIAs 44 & 50. The Foster Creek Conservation District has moved ahead to collect salmonid distribution information on the local level and the results of these efforts are detailed in this chapter. Hydrology is unique in the watersheds. Streams are intermittent and shaped by high flow events. Water availability affects the quality and extent of the salmonid habitat. In WRIA 44 & 50 Foster Creek, Corbaley Canyon (locally known as Pine Canyon), Sand Canyon, Rock Island, and Moses Coulee have been identified as having some degree of salmonid use. The chapter briefly discusses salmonid distribution in the Columbia River but acknowledges the river is being addressed on a regional level and is out of the scope of this document. WRIA 50, north of the Columbia River lies outside of Douglas County within the Colville Indian Reservation and is not addressed in this report.

Chronological History of Salmonid Inventory Efforts in the Foster and Moses Coulee Watersheds

<u>1992 Washington State Salmon and Steelhead Stock Inventory (SASSI)</u>

The 1992 Washington State Salmon and Steelhead Stock Inventory (SASSI 1993) documented the results of an initial stock status inventory that was the first step in a statewide effort to maintain and restore wild salmon and steelhead stocks and fisheries. The effort was spearheaded by Western Washington tribes and the Washington Department of Fish and Wildlife. The purpose of the inventory was to help identify currently available information on naturally reproducing anadromous salmonid populations and to guide future restoration efforts. The inventory is a compilation of data on all wild stocks and a scientific determination of each stock's status as *healthy, depressed, critical, unknown, or extinct*. In 1998 the Washington Department of Fish and Wildlife produced an additional volume on bull trout and Dolly Varden, and with this inclusion of salmonid fishes which are neither salmon nor steelhead, the inventory was renamed the Salmonid Stock Inventory (SaSI). <u>Neither 1992 SASSI nor the 1998 SaSI includes any WRIA 50 or WRIA 44 tributaries.</u>

Much has changed since 1992. The Upper Columbia Steelhead was listed as Endangered in August 1997. Bull Trout in the Columbia River were listed as Threatened in June 1998 and the Upper Columbia Spring Chinook Salmon were listed as endangered in March 1999.

Foster Creek Conservation District Map Updating Party

In 1999, the Foster Creek Conservation District held a salmonid fish distribution map updating party to incorporate current, local expertise on salmonid distribution. State, federal, Public Utility District (PUD), and tribal biologists with expertise were invited to attend. Fish distribution maps for WRIA 44 & 50 were provided which included existing fish distribution data from the Washington State StreamNet and SASSI/SaSI databases, provided by WDFW. There were no other known sources of electronic data on fish distribution available from any local, state, federal, tribal, PUD, or private entity. Participating biologists were asked to review the data and edit the information to reflect current knowledge. Bob Steele (WDFW), Ken Williams (retired, WDFW), and Jerry Marco (Colville Confederated Tribes) offered their expertise. However, biologists were not together in the same room at the same time and did not reach consensus.

Foster Creek Conservation District Salmon Forum

On October 30, 2000 the Foster Creek Conservation District held a Salmon Forum to bring technical fish experts and private landowners together and discuss fish distribution in WRIA 44 and 50. The goal was to get a consensus opinion on fish distribution. Fish experts and landowners worked off of the revised map that was generated at the updating party. Bob Steele was the only original biologist present from the 1999 effort. The additional information gathered at the October 2000 map updating party was digitized into electronic coverages for each species (APPENDIX A). Fish distribution tables (APPENDIX B) are also provided. The tables document the sources of the information in the fish distribution maps. This chapter describes the most current, known salmonid distribution for WRIA 44 & 50 concluded at the October 30, 2000 meeting. Audiotapes are available of the Salmon Forum meeting and can be acquired at the Foster Creek Conservation District Office in Waterville, WA.

Known Salmonid Distribution in the Foster and Moses Coulee Watersheds, WRIA 50& 44

Table 1 summarizes current known spring chinook, summer/fall chinook, summer steelhead/rainbow trout, coho, sockeye, and bull trout distribution in the Foster and Moses Coulee watersheds by stream. More detailed identification of distribution on a reach basis is available in the following text, the fish distribution maps (APPENDIX A), and the fish distribution tables (APPENDIX B).

Table 1. Known Salmonid Distribution in WRIA 50 and 44

STREAM NAME	WRIA STREAM INDEX	Spring Chinook	Summer/ Fall Chinook	Summer Steelhead /Rainbow	Coho	Sockeye	Bull Trout
Foster Creek	50.0065	X	X	X			
Corbaley Canyon (Pine Canyon)	44.0779			X			
Sand Canyon	44.0756	X	X	X			
Rock Island	44.0630	X	X	X			
Moses Coulee	44.0002	X	X	X			
Columbia River	44.0001/ 50.0001	X	X	X		X	X

Appendix A contains twelve maps showing the distribution of spring chinook, summer chinook, summer steelhead/ rainbow trout, coho, sockeye, and bull trout for each WRIA. It reflects knowledge current as November 2000. All upper extents of distribution should be considered approximate. The twelve fish distribution tables for each WRIA (one for each species) in Appendix B provide more detailed information on the source of data shown in the distribution maps.

Steelhead Trout (*Oncorhynchus mykiss)*: Anadromy Versus Residency

Rainbow trout and steelhead are different forms of the same species, *Oncorhynchus mykiss*. All offspring from *O. mykiss* (steelhead/rainbow trout) have the adaptive potential to leave freshwater, migrate to the sea, and return to freshwater to spawn (anadromy; Chapman et al. 1994). With juvenile *O. mykiss*, where there is no barrier to downstream migration, it is impossible to determine whether juveniles will express anadromy or residency. Therefore all juvenile of this species are considered potential steelhead if observed in stream reaches where there are no barriers to downstream migration.

The extent to which anadromy is genetically or environmentally determined is not clear. Thorpe (1987) reported that whether a juvenile *O. mykiss* will smolt and go to sea or mature and remain in freshwater is genetically defined, but subject to environmental instructions. Mullan et al. (1992) reported that the length of freshwater residence of *O. mykiss* in the mid-Columbia region before smolting, depended upon the water temperature of the habitat in which juveniles rear, with fish in colder habitats of watersheds tending toward longer rearing and residency (i.e. the headwater reaches of the Methow watershed). Mullan et al. (1992) stated that most fish that do not emigrate downstream early in life from the coldest environments are thermally-fated to a resident (rainbow trout) life history regardless of whether they were the offspring of anadromous or resident parents. Chapman et al. (1994) reported that Ken Williams (WDFW, retired), a co-author of Mullan et al. 1992, believes that the steelhead/rainbow form (resident or anadromous) is a function of environment rather than genotype. Williams observed a variation in forms over the thermal range in the Methow River (less anadromy further upstream where it is colder) with smoltification occurring in one to three years in warmer mainstems or taking seven years in cold headwaters (Peven 1990; Mullan et al. 1992).

The expression of anadromy can also be affected by barriers that prevent upstream migration of adults to spawning areas or downstream emigration of juveniles toward the ocean. Barriers can be naturally occurring, like waterfalls, steep impassable gradients, or large logjams, or human-caused, like impassable hydro or water diversion dams or culverts. Barriers also include instream flow conditions and high water temperatures (thermal barriers). Barriers can create passage concerns every year or only on certain years under certain conditions. If conditions change (i.e. flows increase, dams are redesigned), offspring of once locked- in rainbow trout may smolt.

Coho in the Upper Columbia

Coho salmon were extirpated from the upper Columbia River around the turn of the century. The last release of juvenile coho were around 1990 from the Turtle Rock hatchery located at Columbia RM 474, one mile upstream from the Rocky Reach Dam, operated by WDFW and funded by the Chelan PUD. Coho found in Sand Canyon and Rock Island Creek during the 1970's and 1980's are assumed to be hatchery fish. There are no self-sustaining runs of coho in the upper Columbia and it is highly unlikely that any coho remain in the system (C. Peven, Chelan PUD; S. Bickford, PUD #1 of Douglas County, pers. comm., 2001).

Overview of Hydrology and Salmonid Distribution

Although hydrology of the watershed is described in the *Watershed Characteristic and Conditions Chapter* it is important to note again the unique hydrology of WRIA 44 & 50 and reiterate how this water availability affects the quality and extent of salmonid habitat.

Steams in WRIA 44 & 50 are intermittent, feed by spring season runoff or a spring system. Perennial flows may occur some years but are unlikely throughout the entire stream reach. The existing stream corridors have been shaped and continue to be reshaped by high flood events. Storms of extreme intensity and short duration occur in the watersheds causing high flood events. Flood events are causes by two distinct climatological patterns: summer thunderstorms or a warm rain-on-snow storm events

(KCM 1995; Johnson 1974). The extent, if any, to which this condition is exacerbated by human land-use activities, is unknown.

Salmonid use, in WRIA 44 & 50 is primarily based on water availability as it affects the quality, extent, and access to salmonid habitat. It is typical for spring chinook and summer/ fall chinook fry or juveniles to stray and enter the mouth of small streams along the Columbia River, in years when flows are present, to rear, escape high flows, escape predators, and to find food and cover. Streams in WRIA 50 & 44 do not support summer/fall chinook spawning, given the natural lack of suitable habitat and hydrology during spawning season (September/October for summer/fall chinook), except perhaps in the alluvial fans formed at the mouth of tributaries to the Columbia River. It is even unlikely that spring chinook, which spawn in August and October, could successfully spawn and reproduce in WRIA 44 & 50 streams during most years, given the natural lack of hydrology, except again, perhaps in the alluvial fans. Steelhead, which migrate to spawning grounds in early spring can take advantage of high flows during spring runoff, and can penetrate up into Columbia River tributaries and smaller watershed streams where there may be gravel deposits suitable for steelhead spawning. Still, hydrology must be present to prevent dewatering of the redds prior to emergence of fry in late August. Eggs in the gravel are also always subject to flood events that can scour out channel beds, destroying redds. In summary, salmonid use is limited to the lower stream reaches and alluvial fans of the tributaries to the Columbia River, with the potential for steelhead to continue upstream during spring runoff high flows (TAG 10-30-00). There is the potential for chinook and steelhead to spawn in the alluvial fan formed at the mouth of any tributary to the Columbia River, given the appropriate conditions. The extent to which human land-use activities in the watersheds are negatively affecting fish use in these habitats is unknown (TAG 10-30-00; TAG 11-21-00). No other potential salmonid-bearing streams were identified at the October 30, 2000 Salmon Forum. However, this cannot be used as confirmation of fish absence but rather as a lack of information.

Definition of terms used to describe fish distribution.

The terminology is consistent with the terms used in the Salmon and Steelhead Habitat Inventory and Assessment Program (SSHIAP), being conducted by the Northwest Indian Fisheries Commission (NWIFC) in cooperation with WDFW and many other state and federal agencies, timber companies and other private groups. More information on SSHIAP can be found at their website www.nwifc.wa.gov/sshiap**.**

Known: Includes habitat where the presence of salmonids has been documented by published sources, survey notes, biologist observations, or TAG knowledge. This includes habitat used by any life stage for any length of time, including intermittent streams that only contain water during peak flows when they provide off-channel refuge habitat.

Presumed: Includes habitat for which there are no known documented records or sightings, but which is downstream of any known fish passage barrier (including sustained 8% or 12% gradient), and otherwise conforms to species-specific habitat criteria.

Potential/
Historic: Includes habitat upstream of human-caused fish passage barriers or downstream of natural fish passage barriers (including sustained 8% or 12% gradient), and otherwise conforms to species-specific habitat criteria.

Survey Work in WRIA 44 & 50

There have been no formal or standardized fish distribution or stream habitat surveys in Foster or Moses Coulee watersheds. There has been some incidental fish presence and stream channel habitat data collected during the 1970's and 1980's, by Bob Steele, biologist for WDFW. Most of Bob Steele's survey work was typically collected as part of Hydraulic Project Application (HPA) investigations, such as culvert installation or trail work. The information was never intended to be incorporated into any formal report but exists only in Steele's field notebooks. It is likely that habitat conditions have drastically changed over the past 20 to 30 years since Steele's data was collected. In this report, other technical fish experts, biologists, and landowners have provided additional input based on their personal and professional knowledge of the area.

Foster Creek

- Known summer steelhead spawning and rearing up to the diversion dam at RM 1.5

- Known spring chinook, summer/fall chinook rearing only up to the diversion dam to RM 1.5

The mouth of Foster Creek has been channelized and riprapped with rock and wire mesh. Floods and heavy construction associated with the installation of culverts at the mouth of Foster Creek have altered the stream channel dramatically. It is suspected that the 1989 flood may have resulted in the development of the massive gravel deposit at the mouth of Foster Creek and may currently limit or preclude fish access to the 1.5 mile reach to the irrigation dam. Low instream flows may also block access to the lower 1.5 miles of Foster Creek where the large gravel deposit contributes to surface flows going subsurface at the mouth (Bob Steele, WDFW, Joe Kelly, U.S. Bureau of Land Management; TAG 10-30-00; Thompson and Ressler 1988).

The Army Corps of Engineers (COE) was planning to replace large culverts on federal land at the mouth of Foster Creek. Foster Creek enters the Columbia River at RM 544.6, approximately 0.5 miles downstream of the Chief Joseph Dam (RM 545.1). Bob Steele, WDFW fish biologist, reviewed the proposed project for impacts to existing fish species in the early-to-mid 1980s. Steele electroshocked the first 1.5 miles of Foster Creek with Bob Fisher, COE fish biologist. At RM 1.5, there is an irrigation dam built upon natural falls, that is a full barrier to all fish passage (TAG 10-30-00). In the stretch below the diversion dam, Steele found watercress, and good populations of juvenile spring chinook, summer/fall chinook, and steelhead throughout the entire reach. He also found flows in the stream channel, probably spring feed. It is Steele's professional opinion that all species of native fish using the mainstem Columbia River could use the section of Foster Creek below the irrigation dam (Bob Steele, TAG 10-30-00).

Born at the mouth of Foster Creek in 1924, Harry Lee Hanford remembers catching a 52-pound salmon in the Columbia River at the mouth of Foster Creek around 1935. This was before the construction of the Grand Coulee Dam. Harry Hanford spent a considerable amount of time up and down Foster Creek and remarks there is a "500 to 1 chance of catching a salmon in the Columbia (rather) than in Foster Creek" (Harry Lee Hanford, TAG 10-30-00).

Above the irrigation dam on Foster Creek (RM 1.5), Bob Steele did survey work with the Washington State Department of Transportation (DOT) when reviewing a proposal by DOT to replace a State Highway 17 bridge crossing on Foster Creek that had been washed out by high flows. Steele did a series of stream transects upstream of the washed-out bridge, which included the stream in the vicinity of Leahy Junction (intersection of State Highways 17 and 174, approximate RM 18). Steele found no anadromous salmonid species or rainbow trout above the irrigation diversion at RM 1.5. He did find one adult brown trout (18 inches in length). Brown trout are a non-native European species planted by WDFW for recreational fishing. According to fish stocking reports from 1940-1975 (Leslie Sikora, pers. comm., WDFW, 2000), trout species including rainbow, eastern brook, brown, and summer-run steelhead stock were planted by WDFW throughout the Foster Creek drainage. It is Steele's professional opinion that it is questionable whether salmonids could survive in the stream reach he surveyed, given the low flows and direct solar exposure (Bob Steele, TAG 10-30-00).

Carol Gross has lived on Foster Creek above the dam since 1951 and has never seen a fish in Foster Creek. She described Foster Creek as having "high runoff and muddy water in the winter"(Carol Gross, TAG 10-30-00).

Steele did some survey work in East Foster Creek on state land where he found adult rainbow trout associated with a spring system. It is unlikely the trout were naturally reproducing. Instead by instead they were probably planted by WDFW or possibly individuals with access to rainbow trout. Steele also found rainbow trout in West Foster Creek (Bob Steele, TAG 10-30-00).

Corbaley Canyon (locally known as Pine Canyon)

- Known rainbow trout rearing and spawning up to approximately RM 6.
- Potential summer steelhead up to approximately RM 6, in years when sufficient instream flows exist to allow upstream migration of spawning adults or downstream emigration of smolts.

In a one-mile reach of Corbaley Canyon (approximately RM 5), Bob Steele electroshocked and netted juvenile steelhead/rainbow trout in the fall of 1999 during review of a project proposed by the DOT. The steelhead/rainbow trout Steele found in Corbaley Canyon ranged in size from 2 to 7 inches and were of various size (age) classes indicating reproduction was occurring. A lack of flows is the only barrier to downstream fish passage from the electroshocked stream reach. On years when flows are adequate to allow fish passage, adult steelhead could migrate upstream to spawn in Corbaley Canyon and juvenile steelhead/rainbow trout could emigrate downstream.

Corbaley Canyon goes subsurface in the lower reaches except during rain-on-snow events, spring run-off or summer storm events. This limits fish passage to periods when water is present making it uncertain whether an annual group of smolts emigrate from the system. If emigration occurs, it could be offspring of the resident rainbow trout population sampled by Bob Steele. It is uncertain the extent to which human land-use activities in the subwatershed may be exacerbating low flow conditions in lower Corbaley Canyon. It is Steele's professional opinion that in the past, perennial flows in Corbaley Canyon were more common and persisted longer into the season following spring snowmelt (Steele, TAG 10-30-00).

The WDFW stocked trout including rainbow trout from 1940-1944 (Leslie Sikora, pers. comm., WDFW, 2000).

Sand Canyon

- Known summer steelhead, and spring chinook, summer/fall chinook rearing up to State Highway 28 stream crossing (RM 0.25).

- Potential steelhead spawning up to State Highway 28 stream crossing (RM 0.25).

Bob Steele sampled Sand Canyon Creek several times in the early-to-mid-1990s. He found juvenile chinook salmon and juvenile steelhead/rainbow trout from the mouth upstream to an impassable culvert/irrigation diversion at State Highway 28. The combined culvert/ irrigation diversion has a head gate 3 to 4 feet above the bed of the stream. Steele found steelhead/rainbow trout juveniles above the barrier that are most likely planted rainbow trout (Steele, TAG 10-30-00). There were more juvenile chinook salmon than juvenile steelhead/rainbow that had strayed into Sand Canyon Creek from the Columbia River. Steele also found juvenile coho in Sand Canyon Creek that are assumed to be hatchery plants naturalized from the Turtle Rock fish hatchery even though they were not marked as hatchery fish (Steele, TAG 10-30-00). Coho have been extirpated from the upper Columbia system at the turn of the century (C.Peven, pers. comm., 2001).

Sand Canyon is naturally a seasonal stream that carries spring runoff, generally going dry by early-to-mid-summer except for when instream flows are generated by heavy summer storm events. However, at present instream flows are maintained through the irrigation season below RM 0.5 (approximately late March to October) by irrigation return flows into Sand Canyon from the Wenatchee Reclamation District Irrigation Canal. These flows, which maintain a colder consistent temperature compared to natural stream temperature, (Bob Steele, TAG 10 -30-00) attract rearing salmonids from the Columbia River, providing rearing habitat in a tributary to the Columbia River that normally would be dry. The loss of irrigation return flows into Sand Canyon would eliminate summer flows in

Sand Canyon Creek and would have a detrimental effect on salmonids in Sand Canyon (TAG 10-30-00).

Rock Island

- Known summer steelhead, spring chinook, summer/fall chinook rearing up to approximately RM 0.5 – 0.75
- Presumed steelhead spawning up to approximately RM 0.5 – 0.75.

In the 1980's, Bob Steele found juvenile steelhead, large resident rainbow trout, juvenile spring chinook, juvenile summer chinook, and juvenile coho in the lower reach of Rock Island Creek. Steele also found carcasses of spawned out coho salmon in the lower reach of Rock Island Creek. Steele has never seen evidence of any other salmonid species spawning in Rock Island Creek, besides coho salmon. Steele assumes the coho found in Rock Island Creek have naturalized from planted stocks from the Turtle Rock Hatchery coho production program even though these fish did not have hatchery fish markings and had not been fin-clipped. Coho have been extirpated from the upper Columbia system at the turn of the century (C. Peven, pers. comm., 2001).

There is a spring up welling about 0.5 – 0.75 miles upstream from the mouth of Rock Island Creek that maintains a perennial flow. River mile 0.5- 0.75 to the mouth of Rock Island Creek can be productive for salmonids.

From 1976-1979, Bob Steele surveyed an isolated rainbow trout population in Rock Island Creek at the top of Badger Mountain. During these surveys, Steele found various size classes of rainbow trout including individuals up to 17 inches long. It is Steele's professional opinion that these rainbow trout are native red-band or "desert-type" rainbow that have adjusted to the high water temperatures of the Rock Island Creek drainage. Various size classes of rainbow trout indicate a spawning population but Steele is concerned that the rainbow trout population in the upper Rock Island Creek drainage could have diminished in the past 25 years. During years of high water availability, it is possible that instream flows may be present to allow access by steelhead trout from the mouth of Rock Island Creek upstream into the upper reaches of the drainage. This would make the isolated rainbow trout population in upper Rock Island Creek accessible to spawning adult steelhead that might be drawn into Rock Island Creek by high spring flows (Steele, TAG 10-30-00).

The largest rainbow trout seen by Lucy Keene in Rock Island was about 11 inches. Lucy Keene is a life-long resident of Douglas County, whose family homesteaded Rock Island Creek.

The WDFW stocked resident rainbow trout, eastern brook, and trout/char species in Rock Island Creek from 1936-1979 (Leslie Sikora, WDFW, pers. comm., 2000). Rock Island Creek contains a good population of trout (Isaacson 1989).

Moses Coulee

- Known summer steelhead, spring chinook, and summer/fall chinook rearing up to approximately RM 1.0.
- Potential summer steelhead rearing to Douglas Creek (RM 19.3) and up Douglas Creek (RM 1.0).

Bob Steele sampled sections in the lower 19.3 miles of Moses Coulee in the late 1970s. Steele found juvenile salmon and steelhead upstream approximately one mile from the confluence with the Columbia River. There was flow in the lower 19.3 miles at that time. Steele has never observed chinook salmon further upstream than RM 1.0, although he has found juvenile steelhead/rainbow trout upstream of RM 1.0 (Steele, TAG 10-30-00). It is Steele's professional opinion that salmonid use except for potential steelhead is limited by high instream temperatures to the first mile of Moses Coulee.

Since the late 1970s, the channel has been altered by major floods events and instream flows are only present during spring run-off (Steele, TAG 10-30-00). According to local rancher Dave Billingsley, the Moses Coulee only flows during spring runoff and summer storm flood events and very seldom is there "total continuity in flows"(Dave Billingsley, pers. comm. 2000). Steele believes during spring runoff, Moses Coulee has the potential to allow migrating steelhead trout access to Douglas Creek. To date, Steele, has never observed an adult steelhead in Douglas Creek, nor has there ever been evidence of adult steelhead in Douglas Creek (Steele, TAG 10-30-00).

Around 1998, Bob Steele surveyed for fish in Douglas Creek. Previous to the time of his survey, there had been a "concrete plug"(most likely an expired irrigation dam), that acted as a barrier to fish passage, in Douglas Creek at RM 0.75. At the time of Bob Steele's survey in 1998, the dam had been partially breached and scoured out underneath. Steele observed juvenile rainbow trout both above and below the breached dam. With this barrier gone, Steele believes there is the potential for steelhead to access Douglas Creek, upstream of RM 0.75, during high spring flows, and inter-mix with the native rainbow trout population in Douglas Creek. (RM 19.3). According to Steele, there are a series of waterfalls on Douglas Creek He has not had the opportunity to survey for fish passage feasibility. The first falls are at Douglas Creek RM 1.0 (Steele, TAG 10-30-00).

Steele believes the rainbow trout in Douglas Creek are native, not of hatchery origin. He knows WDFW has stocked the creek but does not believe hatchery stock would have persisted in Douglas Creek given the instream conditions. "After all", he remarks, "they don't make hatchery fish that good". Steele believes the rainbow trout in Douglas Creek are a native fish adapted to the warmer temperatures of the watershed. Overall the population is isolated in the upper reaches. The biggest fish Steele found in Douglas Creek was a 22-inch resident rainbow trout, found in a pool in the lower canyon (Steele, TAG 10-30-00).

Steele's assessment of the origin and isolated status of the upper Douglas Creek resident rainbow trout population are supported by a study conducted in Douglas Creek by WDFW Fisheries Management Division. The purpose of the study was to compare the detrimental affects of various popular fish tags on both the fingerlings and adults of a wild trout population in a field setting. Douglas Creek's upper reaches were chosen as a sample location for its high trout densities, availability of both fingerling and adult age classes, **absence of anadromy**, and easy access for sampling (T. Jackson and S. Jackson 1994). In the report, Douglas Creek is described as a small spring-fed stream with the upper reaches flowing year around. Its lower reaches are described as being "extensively used for irrigation and cease to flow during dry summers" (Gaines 1987). Occasionally, high spring flow will make it to the Columbia River (T. Jackson and S. Jackson 1994).

However, the 'upper reaches' of Douglas Creek are very productive and large numbers of wild rainbow trout thrive there (Isaacson, 1989; T. Jackson and S. Jackson 1994). A variety of different anomalies were observed repetitively within the population of resident trout in Douglas Creek during the comparative tagging study. The study site consisted of eight continous100 meter sections that were electroshocked in April, May, June, July, and October of 1993 in order to determine loss from the sample population, tag retention, and movement. Anomalies observed include dorso-lateral displacement or pectoral fins, growth on head somewhat similar to a unicorn, deformed mandible, deformed back hump, double adipose fins, and double upper caudal fins. (Terry Jackson, WDFW, Habitat Management via letter to Art Johnson, Dept. of Ecology, December 13, 1996).

The WDFW stocked eastern brook, rainbow trout, and trout species (exact trout species unknown) in Douglas Creek from 1933-1969 (Leslie Sikora, WDFW, pers. comm., 2000).

Columbia River

Upper Columbia River

Salmon, steelhead and bull trout distribution in the Columbia River is briefly described in this chapter. Habitat factors in the mainstem Columbia River that may be limiting salmonid populations in the Upper Columbia River region are not addressed in this report. Habitat factors in the Upper Columbia River are being addressed in other forums at the state and regional level and are outside the scope of this document.

The upper Columbia River serves as a migration corridor and rearing habitat for adult and juvenile spring chinook, summer/fall chinook, summer steelhead and sockeye, and as a thermal refuge for overwintering adult summer steelhead. It also serves as a migration corridor and rearing habitat for adult fluvial bull trout (SaSI, 1998; Mongillo 1992; Brown 1992), although numbers of fluvial bull trout using the upper Columbia River are most certainly reduced to a tiny fraction of the pre-hydroelectric dam era (Brown 1992). Presently, there are no known records of documented bull trout occurrence in tributaries to the Columbia River that fall within WRIA 44 & 50 (Mongillo 1992; TAG 2000).

There is spawning by summer/fall chinook (Chapman et al. 1994 ; Peven 1992, Appendix C; Giorgi 1992) and steelhead (B. Steele, WDFW, pers. comm., 2000) in the mainstem Columbia River. Summer/fall chinook salmon spawning has been documented to occur below Wells Dam, Chief Joseph Dam, at Chelan Falls and potentially on alluvial fans at the mouths of tributaries to the Columbia River, especially the Wenatchee River (Steele, WDFW, pers. comm. 2000). In the fall of the mid-1980s Bob Steele, WDFW, documented six salmon redds on an alluvial fan near Dry Creek (approximate RM 543). He did not observe the adult spawners, but based on the time of year he observed the redds, he believes them to be summer/fall chinook redds. He also observed redds in this same fan during the spring, which he believes to be summer steelhead redds based on the time of year he observed them. These observations were not part of a formal survey effort but represent single observations at a point in time.

<u>Columbia River Upstream of Chief Joseph Dam, downstream of Grand Coulee Dam (RM 596.6)</u>

- Potential/ historic coho, sockeye, and summer steelhead rearing given fish passage at Chief Joseph Dam (Steele, TAG 10-30-00).

- Potential/ historic spring chinook, summer/ fall chinook spawning given fish passage at Chief Joseph Dam (Steele, TAG 10-30-00). Prior to the construction of Chief Joseph Dam, sockeye salmon historically spawned in the Nespelem River (RM 583.0; Chuck Jones, TAG 10-30-00).). The Nespelem River, a tributary to the Columbia River, is located in Okanogan County on the Colville Indian Reservation and is included in WRIA 50. Additional chinook salmon spawning was also likely in the tributaries to the Columbia River upstream of Chief Joseph Dam given fish passage at Chief Joseph Dam (Steele, TAG 10-30-00).

- Known Bull Trout: The USGS is conducting fish species sampling as part of their investigation of gas saturation levels below Grand Coulee Dam (RM 596.6) and above Chief Joseph Dam (RM 545.1). Three bull trout were collected in the 1998 sample between Grand Coulee and Chief Joseph Dams. Three bull trout were identified in the Columbia River reach between the two dams during the1998 sampling period (Chuck Jones, Douglas County, pers. comm.,2000).

<u>Columbia River from Chief Joseph Dam (RM 545.1) downstream to RM 447.0, one mile downstream of the Moses Coulee confluence (RM 447.9)</u>

- Known summer steelhead, spring chinook, summer/ fall chinook, sockeye, and bull trout rearing.

- Known summer/ fall chinook and steelhead spawning.

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HABITAT LIMITING FACTORS BY SUBWATERSHED

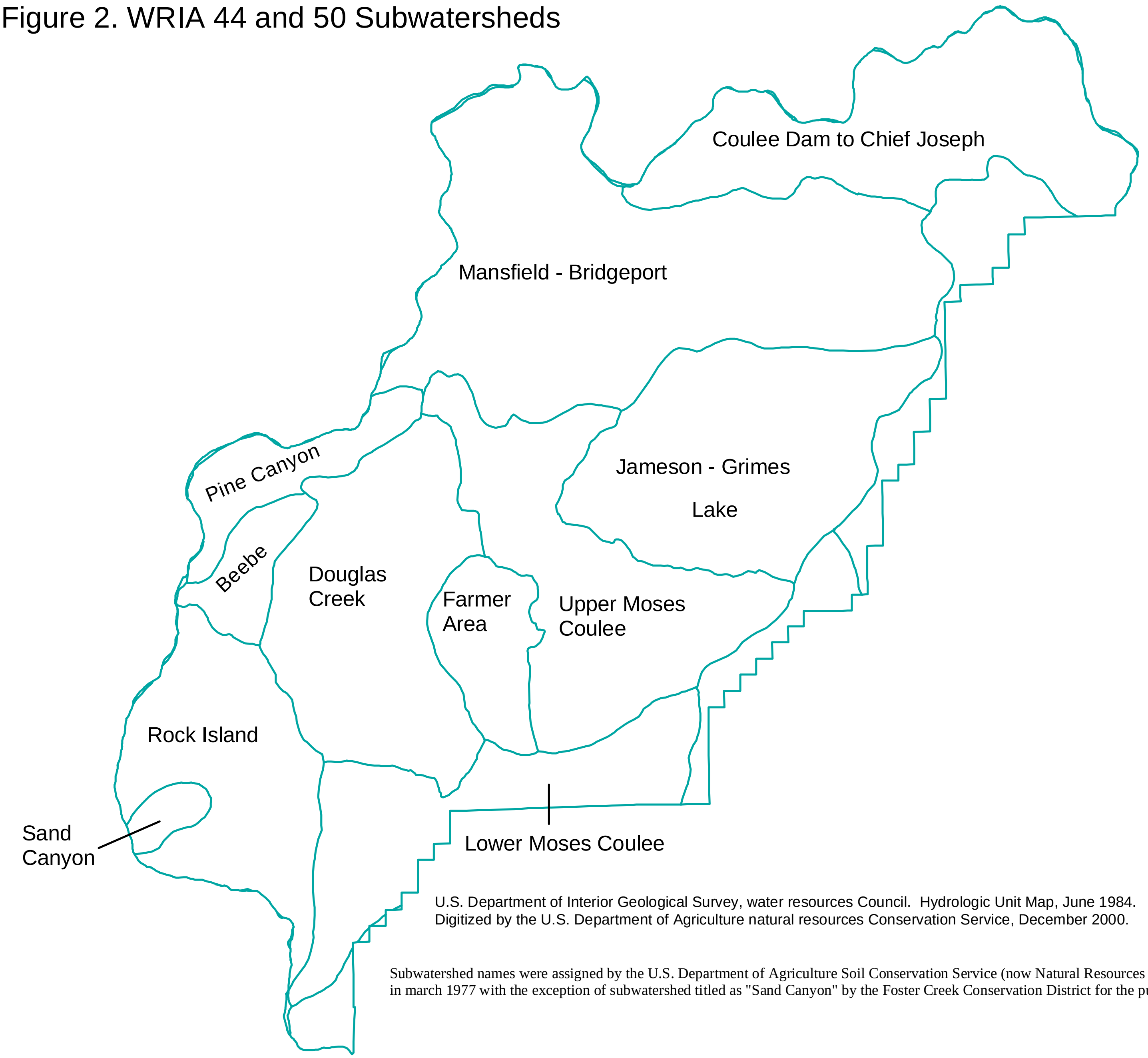
Introduction

This chapter identifies the known habitat factors limiting salmon, steelhead and bull trout performance within eleven of the twelve subwatersheds of Water Resources Inventory Areas (WRIAs) 50 and 44 (Figure 2). Data gaps and recommendations for future projects are included at the end of the chapter. The three subwatersheds within the Foster WRIA 50 are the *North Side Columbia River*, *Mansfield-Bridgeport*, and *Coulee Dam to Chief Joseph*. The nine subwatersheds of Moses Coulee WRIA 44 are the *Beebe, Pine Canyon, Sand Canyon, Rock Island, Douglas Creek, Farmer Area, Lower Moses Coulee, Upper Moses Coulee*, and *Jameson-Grimes Lake*. The WRIA 50 *North Side Columbia River* subwatershed located in Okanogan County and a small portion of WRIA 44 located in Grant County are not included in this report. Small portions of WRIA 40 and WRIA 42 are located within the Douglas County boundaries but are not addressed in this report. WRIA 40, located within Douglas County's southern border, consists of seasonal channels draining directly into the Columbia River that are most likely not salmonid bearing. WRIA 42 on Douglas County's eastern border includes seasonal channels draining into Banks Lake and the chain of lakes locally known as "*Sun Lakes*" and are not salmonid streams. The chapter discusses the habitat limiting factors within each subwateshed of WRIA 44 and 50 within Douglas County.

The legislation governing the development of this report (ESHB 2496) defines habitat limiting factors as "conditions that limit the ability of habitat to fully sustain populations of salmon". The habitat factors limiting salmonid productivity, as identified by the fish experts and landowners present at the October 30th, 2000 Salmon Forum, have been separated into seven categories to identify those areas in need of future study, restoration, or protection. The categories are: 1) Access to Spawning and Rearing Habitat; 2) Floodplains and Channel Conditions; 3) Riparian Condition; 4) Water Quality; 5) Water Quantity; 6) Exotic and Opportunistic Species; and 7) Biological Processes. Based on the information provided in this chapter, Table 2. Assessment of Habitat Limiting Factors appearing in the Assessment chapter of this report provides a rating of the habitat conditions (Good, Fair or Poor).

With WRIA 44 and 50 consisting of 88% private land, documented studies on salmon, rainbow/ steelhead, or bull trout and their habitat, are non-existent with the exception of the Columbia River. This is typical and not unusual for stream reaches not on federal or state land. The information presented here represents a compilation of available data and literature on habitat conditions in the watersheds and includes the combined knowledge of fish experts and landowners serving as the 2496 Technical Advisory Group (TAG). The absence of information for a stream does not necessarily imply that the stream is in good health but my instead indicate a lack of available information. All references to River Miles (RM) are approximate.

Figure 2. WRIA 44 and 50 Subwatersheds



U.S. Department of Interior Geological Survey, water resources Council. Hydrologic Unit Map, June 1984.
Digitized by the U.S. Department of Agriculture natural resources Conservation Service, December 2000.

Subwatershed names were assigned by the U.S. Department of Agriculture Soil Conservation Service (now Natural Resources Conservation Service) in march 1977 with the exception of subwatershed titled as "Sand Canyon" by the Foster Creek Conservation District for the purposes of this report.

Following is a brief synopsis of each of the seven categories of habitat limiting factors. Under each category is a short description of the function and value of that habitat element and a list of conditions that may result from alterations to the habitat. Reading through *Descriptions of Categories of Habitat Limiting Factors* will provide the reader with a sense of the inter-connectedness of the habitat categories and how they relate to productivity of a species and particular life stages. The language in this *Descriptions of Categories of Habitat Limiting Factors* section is meant to identify to the reader with negative impacts to salmonid habitat that can happen when precautions are **not** taken. If the right management practices are identified and properly implemented to avoid the impacts to conditions and functions then the problems are avoided and the issue of negative impacts is irrelevant.

Descriptions of Categories of Habitat Limiting Factors

Access to Spawning and Rearing Habitat.

In general, spring spawning species (rainbow/steelhead) take advantage of high spring flows, accessing smaller tributaries, headwater streams and spring snowmelt-fed streams not accessible later in the year. Reproduction of late summer and fall-spawning species (spring chinook, summer chinook, and fluvial bull trout) occurs most frequently in alluvial reaches of larger streams and rivers where groundwater recharge strongly buffers local interstitial and surface water conditions from decreasing flows and increasing or decreasing water temperatures. Incubation of salmonid eggs and fry occurs within the interstitial spaces of gravels in the beds of cool, clean streams and rivers. Once emergence from the gravel is complete, young salmon are mobile, which increases their flexibility to cope with environmental variation by seeking suitable habitat conditions. Mobility is limited however, particularly for fry, so that suitable habitat and food resources must be available in proximity to spawning areas for successful first-year survival. Ideal rearing habitat affords low-velocity cover, a steady supply of small food particles, and refuge from larger predatory fishes, birds and mammals.

Salmon are limited to spawning and rearing locations by natural features of the landscape. These features include channel gradient and the present of certain physical features of the landscape (e.g. logjams). Flow can affect the ability of some landscape features to function as barriers. For example, some falls may be impassable at low flows, but then become passable at higher flows. In some cases, flows themselves can present a barrier such as when extreme low flows occur in some channels; at higher flows fish are not blocked.

Throughout Washington, barriers have been constructed that have restricted or prevented juvenile and adult fish from gaining access to formerly accessible spawning and rearing habitat. These barriers include dams and diversions with no passage facilities, culverts poorly installed or designed, and dikes that isolate floodplain off-channel habitat. Additional factors considered are low stream flow or temperature conditions that function as barriers during certain times of the year. This category includes dams, dikes, culverts, and other artificial structures or conditions that restrict access to spawning habitat for adult salmonids or rearing habitat for juveniles. Included are barriers created by irrigation diversion dams and inadequate screens that allow access to unsuitable areas that result in mortality to salmonids.

IMPROPERLY OR INADEQUATELY INSTALLED CULVERTS:

- prevent access for salmonid fry and parr to off-channel overwinter refuges of ponds, wetlands and small creeks that are often dry during the summer;

- hinder or prevent passage of adult and juvenile fish due to high water velocity, insufficient water depth, elevated outlet or debris accumulation;

- create flows of a greater velocity and/or a shallower depth than that in the natural stream, often resulting in conditions that restrict or prevent the upstream movement of fish;

- cause the erosion and downcutting of the stream due to the relatively high velocity of water exiting the downstream end of a culvert which can also result in the formation of a vertical drop that may prevent fish from accessing the lower end of the culvert.

DIKES, DAMS AND OTHER ARTIFICIAL STRUCTURES:

- block access to salmonid rearing habitat;

- block access to a portion of the floodplain;

- prevent further development of the side channel;

- prevent the recruitment of large woody debris;

- limit spawning gravel recruitment;

- confine the channel, concentrating flows within the mainstem, increasing the erosive nature of the flows. Bed scour within the reach can negatively impact salmonid redds.

IRRIGATION DIVERSIONS AND SCREENS:

- can allow fish to voluntarily or involuntarily move from the parent water body into the surface diversion leading to direct mortality from stranding when water diversions cease (diversion entrainment);

- can create fish passage barriers during periods of low flow, delaying or preventing movement of spawning/migrating adults and rearing juveniles;

- during periods of low flow, diversion of water can contribute to the reduction in available rearing habitat for juveniles;

- during periods of low flow, diversion of water can contribute to increased water temperatures and decreased dissolved oxygen;

- can contribute to stranding of juvenile salmonids;

- maintenance of diversions can require repeated entry into stream channels disturbing spawning gravels and temporarily increasing sediment levels;

- can allow fish to voluntarily or involuntarily move through, under or around the fish screen resulting in loss of fish from the population. This is a function of screen mesh opening size and gaps between the screen frame and canal structure walls (screen entrainment);

- can cause fish to involuntarily come in contact with and be entrapped by the screen surface due to approach velocities exceeding swimming capabilities resulting in direct mortality (impingement).

<u>*Floodplains and Channel Conditions*.</u>

Floodplains

Floodplains are relatively flat areas adjacent to larger streams and rivers that are periodically inundated during high flows. In a natural state, they allow for the lateral movement of the main channel and provide storage for floodwaters, sediment, and large woody debris. Floodplains generally contain numerous sloughs, side channels, and other features that can provide important spawning habitat, rearing habitat, and refugia during high flows.

Off-channel habitat, or side channels, are formed as a by-product of channel migration and woody debris input and sediment accumulations. Side channels are most predominant in stream types located in narrow to wide valleys and constructed from alluvial deposition. These "C" type channels, as described by Rosgen (1996), also have a well developed floodplain (slightly entrenched), are relatively sinuous with a channel slope of 2% or less and a bedform morphology indicative of a riffle/pool configuration. Off-channel habitat provides refuge for rearing juveniles from high flow events that can otherwise flush young fish downstream, potentially into less suitable habitat.

The alluvial fan areas of the floodplain are an important feature of the floodplain, dissipating flow energy and maintaining and creating suitable rearing and spawning habitat over a wide range of flows. Large woody debris (LWD) in an active channel or floodplain creates conditions necessary for plant colonization within an alluvial plain. Large woody debris is a primary determinant of channel morphology, forming pools, creating low velocity zones, regulating the transport of sediment, gravel, organic matter and nutrients and providing habitat and cover for fish (Bisson et al. 1987).

There are two major types of human impacts to floodplain functions. First channels are disconnected from their floodplain laterally as a result of the construction of dikes and levees, which often occur simultaneously with the construction of roads, and longitudinally as a result of the construction of road crossings. Riparian forests are typically reduced or eliminated as levees and dikes are constructed. Channels can also become disconnected from their floodplains as a result of downcutting and incision of the channel from losses of LWD, decreased sediment supplies, and increased high flow events.

The second major type of impact is loss of natural riparian and upland vegetation. Conversion of mature vegetated cover to impervious surfaces, early-mid seral deciduous riparian stands, pasture, and farmed fields has occurred as floodplains have been converted to urban/residential and agricultural uses. This has: 1) eliminated off-channel habitats such as sloughs and side channels, 2) increased flow velocity during flood events due to the constriction of the channel, 3) reduced subsurface flows, and 4) simplified channels since LWD is lost and channels are often straightened when levees are constructed.

Elimination of off-channel habitats can result in the loss of important rearing habitats for juvenile salmonids such as sloughs and backwaters that function as overwintering habitat for spring chinook, steelhead and bull trout. The loss of LWD from channels reduces the amount of rearing habitat available for juveniles. Disconnection of the stream channels from their floodplain due to levee and dike construction increases water velocities, which in turn increases scour of the streambed. Salmon that spawn in these areas may have reduced egg-to-fry survival due to the scour. Removal of riparian zones can increase stream temperatures in channels, which can stress both adult and juvenile salmon. Sufficiently high temperatures can increase mortality of both adult and juveniles.

Channel Conditions

A stream channel represents the integration of physical processes occurring at the watershed level: hydrologic (i.e. precipitation, snow melt); erosional (i.e. debris flows); and tectonic processes (i.e. mass wasting events). The physical processes determine sediment, water, and LWD input to the channel. The channel reflects the combined effects of sediment, bedload movement and composition, water, and large woody debris (LWD) supplied to the channel. At the same time channel form or morphology is naturally constrained both laterally and vertically by valley form, riparian conditions and geology. The ability of the channel to transport and manage sediment, water, and LWD is a function of the channel's morphology and roughness and the input of sediment and LWD (i.e. source, transport or response reaches; Montgomery and Buffington 1993). The channel form will change when any of these characteristics or variables are altered or when the channel is artificially confined or constrained.

Human land use activities within a watershed (i.e. road development, vegetation removal, water diversion) can alter the outcome of physical processes on channel formation and alter the ability of the channel to develop both laterally and vertically. A stream characteristically alternates between deep zones, or pools, and shallow zones, or riffles. In the Pacific Northwest, large woody debris (LWD) has been found to have a significant influence on the formation of pools and channel form (Nelson 1998). For example, the quality and quantity of salmonid rearing and spawning habitat in a stream channel is controlled by the interaction of sediment and LWD with water and the transport of all three components through the channel network. Altering LWD levels or increasing sediment input can result in a decrease in the number and quality of pools, a decrease in the ability of the channel to retain sediment and organic matter, and an increasing width to depth ratio in low gradient reaches. Confining or constricting the stream channel can affect the rate and manner of sediment, LWD, and water transport through the system. It is important to note that habitat conditions in fish-bearing streams are intimately influenced by contributions of sediment and LWD from non-fish-bearing streams within a watershed. In streams in Douglas County, where recruitment of LWD from the upper watershed is naturally very low, the formation of pools and side channels may be more reliant on the characteristics of the underlying geology and morphology as they affect the transport of water and sediment through the system.

Roads can affect streams directly by accelerating erosion and sediment loading, by altering channel morphology, and by changing the runoff characteristics of watersheds. These changes can alter physical processes in streams, leading to changes in streamflow regimes, sediment transport and storage, channel bank and bed configurations, substrate composition and stability of slopes adjacent to streams (Furniss et al. 1991). Sediment entering a stream is delivered chiefly by mass soil movements and surface erosion processes (Swanson 1991). Failure of stream crossings, diversion of streams by roads, washout of road fills, and accelerated scour at culvert outlets are also important sources of sedimentation in streams within roaded watersheds (Furniss et al. 1991).

Agricultural practices and residential/urban development can also affect streams by accelerating erosion and sediment loading to streams and by changing the runoff characteristics of the watershed. Farmed fields left fallow can cause much surface erosion and sediment movement to streams as winter snow melts and runs off, carrying soil into stream channels (Committee on Protection and Management of Pacific Northwest Anadromous Salmonids et al. 1996). This is particularly a problem where riparian vegetation has been removed and the land is farmed up to or though natural drainages. The conversion of riparian habitat to landscaped lawns has the same effect, removing bank stabilizing root mass thereby contributing to accelerated streambank erosion. Riparian vegetation naturally functions as a filter, capturing sediments and buffering the flow of surface runoff into stream channels.

This category includes direct loss of aquatic habitat from human activities in floodplains including filling and draining of wetlands, disconnection of main channels from floodplains through diking, bank hardening (riprap), channel incision, and degradation of riparian habitat. Disconnection of the channel from its floodplain can result from channel incision (downcutting) caused by changes in hydrology or sediment inputs. Other factors relating to channel conditions, like width/depth ratios and streambank conditions, and habitat elements like substrate, LWD, and pool frequency/quality, are not assessed in this report. Because of the lack of stream survey data and professional knowledge regarding these habitat attributes for Douglas County streams, it is not possible to rate habitat conditions at this level of specificity (TAG 2000).

DIKES:

- block access to salmonid rearing habitat;
- block access to a portion of the floodplain;
- prevent development of the side channels and backwater areas;
- prevent the recruitment of large woody debris;

- limit spawning gravel recruitment and,
- confine the channel, concentrating flows within the mainstem, increasing the erosive nature of the flows. Bed scour within the reach can negatively impact salmonid redds.

BANK HARDENING:

- concentrates stream flows;
- transfers energy downstream;
- increases channel bed scour;
- decreases bank stability;
- reduces riparian vegetation as cover and nutrient-energy sources;
- disrupts the run-riffle-pool sequence (Newbury, et al., 1997);
- prevents development and maintenance of salmonid spawning and rearing habitat;

DRAINING OF WETLANDS:

- eliminates surface water storage in overbank areas;
- eliminates available wetland processes which reduce water velocities and remove sediment;
- eliminates recharge of shallow groundwater that supports subsurface flow in dry seasons;
- eliminates overwintering habitat for salmonids.

ROADS, AGRICULTURAL PRACTICES, AND RESIDENTIAL/URBAN DEVELOPMENT:

- increases in percent fine sediments transported by the stream;
- changes in sediment transport and storage by the stream:
- increased deposition of fine sediments on spawning gravel;
- accelerates filling of pools;
- causes an increased width to depth ratio resulting in a wider shallower channel;
- results in an increased chronic delivery of sediment to downstream tributaries;
- accelerates bank erosion.

Riparian Conditions

The riparian ecosystem is a bridge between upland habitats and the aquatic environment and includes the land adjacent to streams that interacts with the aquatic environment. Riparian forest characteristics in ecologically healthy watersheds are strongly influenced by climate, channel geomorphology, and location of the channel in the drainage network. For example, fires, severe windstorms, and debris flows can dramatically alter riparian characteristics. The width of the riparian zone and the extent of the riparian zone's influence on the stream are strongly related to stream size and drainage basin morphology. In a watershed unimpacted by humans, the riparian zone would exist as a mosaic of tree stands of different acreage, ages (e.g. sizes), and species.

Riparian habitats include side channels which offer refuge from adverse winter conditions such as rain-on-snow events/flooding and icing, and often influence the water quality of adjacent aquatic systems. Riparian vegetation provides shade which shields the water from direct solar radiation thereby moderating extreme temperature fluctuations during summer. Riparian vegetation moderates water temperature during winter and may prevent freezing, although leaf drop on deciduous trees does not significantly provide shade in winter. Riparian vegetation helps stabilize banks by maintaining masses of living roots which reduce surface erosion, mass wasting of stream banks and consequently reducing sediment delivered to the stream channel (Platts 1991). Riparian vegetation also contributes to the recruitment of large woody debris (LWD). Large woody debris contributes to channel complexity, including pool development, and sediment storage. Riparian ecosystems act as reservoirs, storing run-off in soil spaces and wetland areas and diminishing erosive forces caused by high flow events. The presence of stream-side vegetation also reduces pollutants, such as phosphorous and nitrates through filtration and binding them to the soil. Riparian vegetation contributes nutrients to the stream channel from leaf litter and terrestrial insects which fall into the water.

Riparian zones are impacted by all types of land use practices. Riparian forests can be completely removed, broken longitudinally by roads, and their widths can be reduced by land use practices. Further, species composition can be dramatically altered when native, old-growth, coniferous trees are harvested, allowing for the establishment of a younger seral stage of hardwood, deciduous tree species and young, smaller diameter conifers. Deciduous trees are typically of smaller diameter and shorter lived than coniferous species. They decompose faster than conifers so they do not persist as long in streams and are vulnerable to washing out from lower magnitude floods. Once impacted, the recovery of a riparian zone can take many decades as the forest cover reestablishes and matures and coniferous species colonize. In the more arid, narrower riparian zones common in the steep canyons of the Douglas County watersheds, reestablishing conditions that support the regrowth of native riparian vegetation can be an even more difficult once the soil is disturbed.

Salmonids habitat requirements are met in part by healthy, functioning riparian habitat. For example: adequate stream flows must be present in order for fish to access and use pools and hiding cover provided by root wads and LWD positioned at the periphery of the stream channel. Microclimate, soil hydration, and groundwater influence stream flow; these factors are in turn influenced by riparian and upland vegetation. Vegetation and the humus layer intercept rainfall and surface flows. This moisture is later released in the form of humidity and gradual, metered outflow through groundwater where the geology supports the groundwater/surface water interaction. Through this process, stream flows may be maintained through periods of drought (Knutson and Naef 1997).

The category *Riparian Conditions* addresses factors that limit the ability of native riparian vegetation to provide shade, nutrients, bank stability, and a source for LWD. Human impacts to riparian condition and function include timber harvest or clearing for agriculture or development, construction of roads, dikes, or other structures, and direct access of livestock to stream channel.

TIMBER HARVEST OR CLEARING (REMOVAL OF RIPARIAN VEGETATION):

- decreases bank stability;
- decreases LWD recruitment;
- results in a loss of shading;
- results in a loss of cold water refugia;
- increases sediment recruitment;
- decreases sources for nutrient input;

LIVESTOCK GRAZING:

- decreases bank stability;
- increases sediment recruitment;
- alters the composition of riparian vegetation;
- compacts soil.

<u>*Water Quality*</u>

Water temperature strongly influences the composition of aquatic communities with salmonids thriving or surviving only within a limited temperature range. Physiological functions are commonly influenced by temperature, some behaviors are linked to temperature, and temperature is closely associated with many life cycle changes. Water temperatures of approximately 23-25 °C (73-77 °F) are lethal to salmon and steelhead (Theurer, et.al., 1985) and genetic abnormalities or mortality of salmonid eggs occurs above 11 °C (51.8 °F). Temperature indirectly influences oxygen solubility, nutrient availability, and the decomposition of organic matter; all of which affect the structure and function of biotic communities. As water warms, oxygen and nutrient availability decrease, whereas many physiological and material decomposition rates increase. These temperature-moderated processes can influence the spatial and temporal distribution of fish species and aquatic organisms (Bain and Stevenson 1999).

Water temperature varies with time of day, season, and water depth. Although temperatures are particularly dependent on direct solar radiation, they are also influenced by water velocity, climate, elevation, location of stream in the watershed network, amount of streamside vegetation providing shade, water source, temperature and volume of groundwater input, the dimensions of the stream channel, and human impact. This category addresses high or low instream water temperatures that negatively affect salmonid migration or survival during any life history stage.

Temperature increases and consequent reductions in available oxygen tend to have deleterious effects on fish and other organisms by: 1) inhibiting their growth and disrupting their metabolism; 2) amplifying the effects of toxic substance; 3) increasing susceptibility to diseases and pathogens; 4) encouraging an overgrowth of bacteria and algae which further consume available oxygen; and 5) creating thermal barrier to fish passage. Human activities like water diversion and upland and riparian vegetation removal, reduce the quantity and quality of riparian vegetation adjacent to stream channels, increase sediment delivery to streams, simplify stream channel characteristics (i.e. pools, off channel habitat, LWD, stream length), and reduce instream flows which can contribute to increased high and increased low water temperatures.

Other water quality parameters that affect salmonid habitat quality, but are not addressed in this category, include fine sediment, dissolved oxygen (DO) levels, the presence of fecal coliform, pH levels and major potential stream pollutants which include nutrients such as nitrates and phosphates, heavy metals from mining waste, and compounds such as insecticides, herbicides, and industrial chemicals. Water quantity (dewatering/low flows, perennial/intermittent flows) is addressed as a separate category. It was the decision of the TAG to not include the other water quality parameters in the assessment process of this report because there is presently very little or no data available for these parameters in WRIAs 50 or 44 streams. It is therefore not known the extent, if any, to which parameters other than stream temperature, may be affecting salmonid productivity.

This category includes only stream temperature as they limit the ability of the habitat to sustain salmonid populations.

WATER DIVERSIONS:

- during periods of low flow, can contribute to increased water temperatures and decreased dissolved oxygen.

REMOVAL OF RIPARIAN VEGETATION:

- decreases LWD recruitment;
- results in a loss of shading;
- results in a loss of cold water refugia;
- increases sediment recruitment.

CHANGES IN UPLAND VEGETATIVE COVER:

- influences snow accumulation and melt rates;
- influences evapotranspiration and soil water content;
- influences soil structure affecting infiltration and water transmission rates.

Water Quantity

Changes in flow conditions can have a variety of effects on salmonid habitat. Decreased flows can reduce the availability of summer rearing habitat and contribute to temperature and access problems, while increased peak flows can scour or fill spawning redds. Other alterations to seasonal hydrology can strand fish or limit the availability of habitat at various life stages. Extended periods of low flows can delay the movement of adults into streams, draining their limited energy reserves, affecting upstream distribution and spawning success. High winter flows can cause egg mortalities by scouring and/or sedimentation of the spawning beds. Low winter flows can contribute to anchor ice formation and result in the freezing of eggs or stranding of fry. The overwinter survival of juvenile fish can be negatively affected by the reduction in the quantity and quality of winter rearing habitat as a result of low flows. Water temperatures can also rise associated with low flows, exacerbated by riparian habitat and channel degradation, resulting in mortalities and stress for fish.

The quantity of available water and the rate at which it reaches the stream channel and passes through the channel system are influenced by precipitation regimes, watershed size, vegetation cover, and certain topographic consideration (Swanston 1991). Loss of flow in a channel or a stream reach can be the result of natural hydro-geologic conditions, the result of human activities, or a combination of both factors. Often the cause or causes of dewatering, when there have been significant alterations in the drainage, is difficult to determine. Altering the vegetative component of a watershed can have a significant effect on the timing and magnitude of peak and low flows. Changes in percent cover, species composition, and/or stand age class can change interception, evapotranspiration and soil water retention rates. Conversion of land to agricultural and urban/residential use, timber harvest activities, road development, and fire are all actions that have the potential to disturb the vegetative community of a drainage to the extent that there is a noticeable affect on surface water runoff patterns and ground water storage patterns. High road densities, soil compaction associated with agricultural activities, timber harvest, and grazing all contribute to increased surface water runoff and decrease soil permeability and water retention. Farming practices such as planting of fields into CRP, leaving high residue levels on cultivated fields, direct annual spring seeding, terraces, sediment ponds, and the use of conservation buffers are aimed at reducing the negative impact of cultivation on water quantity and water quality.

Stream flow is moderated by riparian vegetation as well as vegetative cover in the uplands. Riparian areas, in particular, assist in regulating stream flow by intercepting rainfall, contributing to water infiltration, and using water via evapotranspiration. Plant roots increase soil permeability, and vegetation helps to trap water flowing on the surface, thereby aiding infiltration. Water stored in the subsurface sediments is later released to streams through subsurface flows. Through these processes, riparian and upland vegetation help to moderate storm-related flows and reduce the magnitude of peak flows and the frequency of flooding.

This category addresses changes in flow conditions brought about by water diversions, road construction, and changes in upland vegetative cover.

WATER DIVERSIONS:

- delay or prevent movement of spawning/migrating adults and rearing juveniles;
- reduce available rearing areas for juveniles;
- contribute to increased water temperatures and decreased dissolved oxygen;
- dewater or contribute to low flow conditions downstream of the point of diversion.

ROAD DEVELOPMENT:

- increase magnitude of peak flow events.

CHANGES IN UPLAND VEGETATIVE COVER:

- influences snow accumulation and melt rates;
- influences evapotranspiration and soil water content;
- influences soil structure affecting infiltration and water transmission rates.

Exotic and Opportunist Species

Exotic species are those non-native species which colonize or invade habitats and may have deleterious effects on the native plants and wildlife. Managing and controlling exotic species is important for the maintenance of the integrity of ecosystems, including their function, composition and structure. The introduction of exotic species can result in the alteration of plant and animal communities and their inter-relationships.

Noxious vegetation in Douglas County as of 1997 according to the Natural Resources Conservation Service (NRCS) includes: baby's breath, field bindweed, Canada thistle, Dalmatian toadflax, diffuse knapweed, hairy whitetop, houndstongue, kochia, common mullein, oxeye daisy, perennial pepperweed, purple loosestrife, rush skeletonweed, Russian knapweed, saltcedar, Scotch thistle, and common St. Johnswort. This list of noxious weeds is not all inclusive of exotic species. Noxious weeds are non-native plants that have been introduced to Washington through human actions. Because of their aggressive growth and lack of natural enemies in this state can be highly destructive, competitive or difficult to control. These species can destroy native plant and animal habitat and clog waterways (Washington State Noxious Weed Control Board 1997).

Brook trout are a non-native salmonid introduced into watersheds in Washington State, to improve recreational fishing opportunities. Brook trout occupy the same habitat and hybridize extensively, leading to extirpation of bull trout populations (Mullan et al. 1992) and competition for rearing and spawning habitat. Brook trout are known to mature earlier than bull trout (2 - 4 years for brook trout and 6 - 9 years for bull trout; personal communication, Heather Bartlett, WDFW, 2000) giving them a reproductive advantage.

BROOK TROUT INTRODUCTION:

- extirpation of bull trout populations through hybridization and competition for habitat.

EXOTIC VEGETATION:

- Widespread noxious weeds in riparian areas include reed canary grass and Russian olive. Cheatgrass is also a common weed in WRIA 44 and 50.

Biological Processes.

Beaver had a key role in creating and maintaining conditions of many headwater stream, wetlands, and riparian systems that were fundamentally important to the rearing of salmon (Committee on Protection and Management of Pacific Northwest Anadromous Salmonids 1996). Their dams and ponds created storage locations for water, sediment, and nutrients. Beaver ponds were of particular importance in the more arid region where they also provided rearing habitat for salmon (Committee on Protection and Management of Pacific Northwest Anadromous Salmonids 1996). The general decline of beaver and their associated habitats constituted perhaps the first major impact on salmon populations from the influx of Euro-American. Persistent trapping pressure over the decades has continued to keep beaver populations relatively low (Committee on Protection and Management of Pacific Northwest Anadromous Salmonids 1996). Beaver impoundments stabilize stream flows in two ways: first, they act as reservoirs, increasing the water-holding capacity of the watershed, thus slowing the rate of runoff; second, flooding of land in the vicinity of the beaver colonies raises the level of the water table and the stored groundwater is slowly released back into the stream, which helps to maintain flow during periods of drought. Beaver impoundments have been found to improve the quality and diversity of riparian habitat. A diverse aquatic and riparian vegetation community contributes to fish production by providing escape cover, thereby minimizing mortality from predators; by attracting terrestrial insects, some of which fall to the water surface and are eaten by fish; and, in the case of submerged vegetation, by providing suitable habitat for aquatic insects and other invertebrates that are the principle source of fish food. The activities of beavers are also much involved in nutrient cycling which, in terms of fish production, may be as important as the role they play in moderating stream flows.

Pacific salmon and other anadromous salmonids have been considered a major vector for returning significant amounts of nutrients from the Pacific Ocean back to land (ie., from marine to freshwater and terrestrial ecosystems; Cederholm et al. 1999). As wild spawning salmon numbers decline, it can be assumed that productivity of some freshwater and terrestrial ecosystems will be diminished because of reduced nutrients and biomass returned from the ocean. The fate and utilization of nutrients provided by decomposing salmon carcasses may depend on numerous variables, including species (spawning densities and location in the watershed preferred for spawning), in-stream physical structure (retention of organic debris or otherwise), discharge (high stream flows), biotic mechanisms (consumption by aquatic and terrestrial invertebrates, fish, and terrestrial wildlife), and riparian ecosystem conditions (the amount of light that limits primary productivity) (Cederholm et al. 1999). The impact of this nutrient deficit is difficult to quantify but may deserve consideration in the Foster and Moses Coulee Watershed.

This category addresses impacts to fish caused by the loss of beaver activity and the loss of ocean-derived nutrients from a reduction in the amount of available salmon carcasses.

LOSS OF BEAVER ACTIVITY:

- decreased water storage capacity;
- decreased sediment storage capacity;
- decreased nutrient storage capacity;
- decreased quality and diversity of riparian habitat;

DECREASE IN SALMON CARCASSES:

- reduction in nutrients like phosphorus and nitrogen;
- reduction in available biomass to support aquatic and terrestrial ecosystems.

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Characteristics of WRIA 50 and 44

Although hydrology of the watershed is described in the *Watershed Characteristic and Conditions Chapter* it is important to note again the unique hydrology of WRIA 44 and 50 and reiterate how this water availability affects the quality and extent of salmonid habitat.

Most steams are intermittent, fed by spring runoff or a spring system and shaped by high flow events. Perennial flows may occur some years but are unlikely thought the entire stream reach. The existing stream corridors have been shaped and continue to be reshaped by high flood events. Storms of extreme intensity and short duration occur in the watersheds causing high flood events. Flood events in WRIA 44 and 50 are causes by two distinct climatological patterns: summer thunderstorms or a warm rain-on-snow storm event. Thunderstorms occur primarily during the summer months and normally have high rainfall intensities over relatively small areas (KCM 1995; Johnson 1974). Major thunderstorms typically have peak rainfall intensities as high as 0.5 inches in 15 minutes, 1.25 inches in 1 hour, and 2.0 inches in 90 minutes (KCM 1995). Rain-on-snow events occur in the late winter or early spring, usually with smaller amounts of precipitation; however, with the ground frozen and infiltration prevented, the melting snow combined with rainfall can create a large runoff event. Flooding problems are not widespread, but are occasionally severe on alluvial fans and localized flood plains, which are subject to flash floods. (KCM 1995; Johnson 1974). Major floods have occurred about every 10 years, although smaller storms causing localized damage are more frequent. The largest floods in recent history occurred in 1972 and 1989. Several other events occurred in 1948,1957, 1973, 1975, 1976, 1991, and 1993 (KCM 1995; TAG 10-30-00). In March of 1951, the US Geological Survey (USGS) recorded a peak flow in the Moses Coulee near the Palisades at 1,990 cubic feet per second (3 miles downstream of the Douglas Creek tributary). Average flows were recorded by the USGS at this Palisades station for the years 1953- 1955 (fragmentary records) are below 30 cfs (USGS Annual Flow Data). High flow events generate high instream velocities which have an increased transport capacity relative to the channel's size, slope and the roughness of the channels' features. All streams experience some increase in suspended sediment immediately following precipitation and snowmelt events (Johnson 1974; KCM 1995). Aquatic habitat degradation occurs when the quantity of sediment delivered to a stream exceed the stream's capacity to transport that load through its system. According to local rancher, Sid Viebrock, these problems are site specific rather than universal throughout WRIA 44 and 50. Flows during the rest of the year can be nonexistent (TAG 10-30-00).

Salmonid distribution and use (rainbow trout/steelhead, spring chinook, and summer/fall chinook) in WRIA 44 and 50 is a function of water availability as it affects the quality and quantity of salmonid habitat and access to that habitat. It is typical for spring chinook and summer/ fall chinook fry or juveniles to stray and enter the mouth of small spring feed streams along the Columbia in years when flows are present, to rear, get out of high flows, escape predators, and to find food and cover. Streams in WRIA 50 & 44 do not support summer/fall chinook spawning, given the natural lack of suitable habitat and hydrology during spawning season (September/October for summer/fall chinook), except perhaps in the alluvial fans formed at the mouth of tributaries to the Columbia River. It is even unlikely that spring chinook, which spawn in August and October, could successfully spawn and reproduce in WRIA 44 & 50 streams during most years, given the natural lack of hydrology, except again, perhaps in the alluvial fans. On the other hand, steelhead, which migrate to spawning grounds in early spring, take advantage of high flows during spring runoff, and can penetrate up into Columbia River tributaries and smaller watershed streams where there may be gravel deposits suitable for steelhead spawning. Still, hydrology must be present to prevent dewatering of the redds prior to emergence of fry in late August. Eggs in the gravel are also always subject to flood events that can scour out channel beds, destroying redds. In summary, salmonid use is limited to the lower stream reaches and alluvial fans of the tributaries to the Columbia River, with the potential for steelhead to continue upstream during spring runoff high flow events (TAG 10-30-00). There is the potential for chinook and steelhead to spawn in the alluvial fan formed at the mouth of any tributary to the Columbia River, given the appropriate conditions. The extent to which human land-use activities in the watersheds are negatively affecting fish use in these habitats is unknown (TAG 10-30-00; TAG 11-21-00).

Water levels along the shores of the Columbia River are affected by fluctuating water levels of the Columbia River reservoirs. This affects mostly the alluvial fan areas at the mouth of tributaries to the Columbia River in the Foster and Moses Coulee Watersheds. For example, the Columbia River (Lake Entiat), impounded from the Rocky Reach Hydroelectric Project (RM 473.5) to the Wells Hydroelectric Project (RM 516.5) is typically held at the normal maximum elevation of 707 feet, although it may be drawn down to a minimum of 703 feet (Chelan PUD NO.1 1995). Similarly the Columbia River (Rock Island Reservoir), impounded from the Rock Island Hydroelectric Project (RM 453.4) to the Rocky Reach Hydroelectric Project (RM 473.5) has a maximum elevation of 613.0 feet with a maximum downdraw of 4.0 feet to elevation 609.0 feet (Chelan PUD NO.1 1977). These elevations can be used to calculate the river mile on any tributary up to which the reservoir has a “pooling” effect. The effect of changes in Columbia River reservoir pool elevations is important to note because of its potential impacts to salmonid habitat and access to that habitat in the tributaries. A comprehensive study evaluating of pooling effects on tributary habitat has not been conducted to date for WRIA 44 and 50. Although impacts to Columbia River tributary habitat is within the scope of this report, management of Columbia River water levels is not, but being handled in the hydro arena of the State of Washington salmon recovery planning efforts.

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Subwatersheds

Grand Coulee Dam (RM 596.6) to Chief Joseph Dam (RM 545.1)

The Coulee Dam to Chief Joseph subwatershed contains approximately 132,933 acres. It includes the tributaries to the Columbia; Fiddle Creek, Sanderson Creek, Moses Creek, School Creek, Deep Canyon, China Creek, Stahl Canyon, Alec Canyon, and Jordon Creek.

Access to Spawning and Rearing Habitat

No information available.

Floodplains and Channel Conditions

No information available.

Riparian Zone Conditions

No information available.

Water Quality

No information available.

Water Quantity

No information available.

Exotic or Opportunistic Species

Dalmatian toadflax, diffuse knapweed, St. Johnswort, baby's breath, an saltcedar have been observed in this watershed (Washington State Noxious Weed Control Board Map1997).

Biological Processes

No information available.

Literature Cited:

Washington State Noxious Weed Control Board. 1997. Noxious Weed Survey of Douglas County, Washington.

Mansfield-Bridgeport

The Mansfield-Bridgeport subwatershed contains approximately 213,639 acres. It includes the tributaries to the Columbia River. The portion of the Columbia River that borders this subwatershed is now comprised of two reservoirs, Lake Pateros and Lake Entiat. Named tributaries to these reservoirs are (*LB* is the left bank looking downstream, *RB* is right bank looking downstream):

Lake Pateros

- Foster Creek:
    - *East Foster Creek (tributary to East Foster Creek: Deep Creek (LB))*
    - *Middle Foster Creek (tributaries to Middle Foster Creek: Collins Canyon (LB), Middle Lake, Tootenton Ok (RB), Alkali Wells)*
    - *West Foster Creek (tributaries to West Foster Creek: Chapman Draw (LB). Tributaries to Chapman Draw: Fye Canyon (RB) and Smith Draw (RB)*
- Dry Creek
- Central Ferry Canyon
- Dougherty Canyon

Lake Entiat

- Skeleton Canyon
- Long Draw

Foster Creek is the only known salmonid-bearing tributary to the Columbia River in this subwatershed. It is addressed in this section.

Loss of Access to Spawning and Rearing Habitat

An irrigation dam at approximately RM 1.5 on Foster Creek precludes all fish passage (TAG 10-30-00). A dam was built on Foster Creek in 1909 at a place where a natural falls existed. The new dam was 18 inches higher than previous natural falls. Part of the foundation was blown out so they could fasten the dam to it (Harry Lee Hanford, TAG 10-30-00). There was a major flood in 1989 and construction that may have altered the mouth of Foster Creek dramatically. Heavy machinery was used in the stream and culverts were installed. The mouth of Foster Creek has been riprapped. It is suspect that the 1989 flood may have reshaped the alluvial fan at mouth and may limit or completely block off access to the 1.5-mile reach to the irrigation dam. Low water may also block access to this stretch (Bob Steele, Joe Kelly, TAG 10-30-00,11-21-00; Thompson and Ressler 1988).

Above the irrigation dam on Foster Creek (RM 1.5), Bob Steele did survey work with the Washington State Department of Transportation (DOT) when reviewing a proposal by DOT to replace a State Highway 17 bridge crossing on Foster Creek that had been washed out by high flows. Steele did a series of stream transects upstream of the washed-out bridge, which included the stream in the vicinity of Leahy Junction (intersection of State Highways 17 and 174, approximate RM 18). Steele survey was conducted in the fall when there were low flows, a lack of riparian vegetation and high water temperatures. Steele found no anadromous salmonid species or rainbow trout above the irrigation diversion at RM 1.5. It is Steele's professional opinion that it is questionable whether salmonids could survive in the stream reach he surveyed, given the low flows and direct solar exposure (Bob Steele, TAG 10-30-00).

Floodplains and Channel Conditions

A massive flood in 1989 resulted in the delivery of huge amounts of bedload gravel to the mouth of Foster Creek. Deposited at the mouth, a huge gravel bar developed (RM 0.0 to1.5) (TAG 11-21-00). According to Carol Gross, resident on Foster Creek since 1951, in August 1922 there was a flash flood where a 20-foot wall of water washed down in less than four hours. Four hundred cords of cut firewood washed downstream and the bridge washed out. In 1928 a new road was built up Pearl Hill and a cement bridge was put in place. When the Army Corps of Engineers finished building the Chief Joseph Dam they put in 6 culverts near the mouth of Foster Creek. Two years later they washed out (Carol Gross, TAG 10-30-00).

The floodplains of East Foster Creek have been described by Munson Engineers (1989): "The floodplain, which is the nearly level, is a quarter mile wide corridor through which East Foster Creek flows". The floodplain is generally cultivated with some areas in the Conservation Reserve Program (CRP). The floodplain also contains nearly all the meadows and provides grazing for livestock. The soils in the floodplain are predominantly Aqualls and Umapine Variant that have a moderately high runoff potential. Due to the close proximity of the steam channel and the nearly flat slopes of the floodplain, surface runoff generally flows slowly in sheets in to the steam channel. Erosion in the floodplain is generally low with the exception of downcutting in the East Foster Creek stream channel caused by unrestrained runoff emanating from the uplands and breaks.

When Bob Steele, fish biologist, WDFW surveyed RM 0.0 to1.5 in the mid 1980s as part of a DOT culvert installation project the channel was in 'good condition' (Bob Steele, TAG 10-30-00). Since then, culverts were installed, machinery had been dragged over the stream system, and there have been large flood events altering the system dramatically. The mouth of Foster Creek is riprapped to prevent the stream channel from changing course in high flood events (TAG 10-30-00; TAG 11-21-00).

When the irrigation dam was built on Foster Creek (RM 1.5) a holding pond above the dam was excavated and filled with water in 1948. However, *"Early 1900's before the dam, during flood stages, one could put a plank of wood across from both creeks and walk across it. Now it is quite different."* (Harry L. Hanford, TAG 10-30-00).

The soils throughout the entire East Foster Creek watershed are extremely fine grained. Surface soils are predominantly loam and cobbley loam with a large percentage of silt. The silt fraction of the soils is particularly susceptible to erosion on fallow fields where the soil surface is exposed to rainfall. Once the soil grains are dislodged from the soil mass by rainfall, they are so minute that even sheet flow quickly carries them away, resulting in erosion. The eroded grains are easily transported by runoff in rills, gullies and intermittent stream channels. While being transported by the runoff flow, the soil grains act as fine abrasives and further scour the stream channels, loosening and transporting additional soil grains resulting in headcutting and downcutting (Munson 1989).

The East Foster Creek Watershed Hydrology and Sedimentology Study done by Munson Engineers in 1989 documents most soil grains transported through intermittent stream channels eventually travel through East Foster Creek and on to the Columbia River.

However a few intermittent streams pass through small ponds and reservoirs where the flow slows and the soil grains settle, thereby depositing part or all the sediment load (Munson 1989).

Severe silting and erosion occurs in the Foster Creek watershed. The heavy sediment yields found in this area are caused either by snowmelt or rain erosion of surface soil when the underlying ground is frozen or by high intensity rainstorms in the summer months (Johnson 1974). The extent to which this erosion is exacerbated by human land use practices is unknown.

Riparian Conditions

Before the Chief Joseph Dam, the mouth of Foster Creek to the irrigation dam had cottonwood trees 60- 80 feet tall and 2-3 feet across. There was a 25-acre patch of black cottonwoods at the mouth of Foster Creek (Harry Hanford, TAG 10-30-00).

Presently the riparian zone of the East Foster Creek drainage is largely devoid of large woody vegetation (Thompson and Ressler 1988). In the East Foster Creek Watershed woody riparian habitat today is probably just a small remnant of what once existed. It consists of small copses and short galleries along the courses of both perennial and intermittent streams. In several places only the trunks of long-dead streamside trees are standing. Species historically found were waterbirch (*Betula fontinalis*), aspen (*Populus tremuloides*), hawthorn (*Crataegus douglasii*), willows (*Salix spp*.), and wild roses (*Rosa spp*.) (Thomson and Ressler 1988).

Water Quality

Observations of mainstream Foster Creek above the irrigation dam (RM 1.5): Low flow and high temperatures of which lack of riparian shading is a contributing factor (Bob Steele, TAG 10-30-00). Runoff is high and the water is extremely muddy in the winter (Carol Gross, TAG 10-30-00).

In the Foster Creek drainage, water quality monitoring has only been conducted on East Foster Creek. There are significant water quality and soil erosion problems within the approximately 100,000 acres that comprise the East Foster Creek drainage (Thompson and Ressler, 1, 1988). The soil and water problems are varied; eroding stream banks, channel headcutting, and non-point-source fluvial erosion of cropland and range are all present. Soils in this drainage are fragile and highly erodiable (Thompson and Ressler 1988). Evidence from interviews and field observation indicates that the major water quality problem on East Foster Creek results from episodes of soil erosion that produce considerable turbidity in the creek. Water quality improvement from reduction of turbidity can be achieved in two ways: stopping erosion at its source, and trapping or settling soil particles out after they begin to move downstream (Thompson and Ressler 1988).

Quality of surface waters is directly related to the quantity of water available and inversely related to the surface area (size of watershed) off which it flows and the number of people utilizing that area (Thompson and Ressler 1988). It may also be negatively affected by the uses made of the watershed. Because the East Foster Creek Watershed receives relatively little precipitation in proportion to its area, possible dilution of chemical contaminants is restricted. It is thus possible that certain chemical products such as naturally occurring salts and organic materials as well as non-natural substances such as pesticides and herbicides could appear in higher concentrations in Foster Creek than in an equivalent drainage area with greater precipitation. The severity of contamination of the waters of Foster Creek is poorly recorded, but several observations in the field, although anecdotal, suggest that some contamination must be present (Thompson and Ressler 1988):

1. In late August 1987, two dead cattle were observed lying in the creek above Leahy Junction. Although this was an unusual instance by all accounts, situations like this can contribute biological contaminants (Thompson and Ressler 1988).

2. Approximately one mile downstream from Leahy a large number of dead trees (snags) border the creek. It was suggested that they might have been killed by aerial spraying of herbicides. If this is indeed the case, it suggests that occasional injudicious applications of agricultural chemicals may negatively affect water quality (Thompson and Ressler,1988). According to local resident Carol Gross, these dead trees are in direct result of beaver activity (2000).

3. Large areas of alkali-encrusted soils exist on the middle reach of Foster Creek and its tributaries. Some of these salts are dissolved and carried downstream during the spring runoff (Thompson and Ressler 1988). These alkali-encrusted soils are a natural occurrence (TAG, Katherine March, WDFW).

Chelan-Douglas Health District has measured nitrate concentrations in wells around Mansfield. On seven samples tested in December 1969 and January 1970, the nitrates in Mansfield public water supply system ranged between 40-79 milligrams per liter. Amounts over 45 milligrams per liter exceed nitrate limits set by the U.S. Public Health Service. At this time there was not conclusive evidence as to the source of nitrate problem and nitrate concentration fluctuations (Johnson 1974).

Water Quantity

Beyond spring snowmelt, flows in the Foster Creek drainage are probably sustained by groundwater recharge at springs. Sections of Foster Creek run dry (Bob Steele, TAG 2000). According to local resident on Foster Creek, Carol Gross, "*East Foster Creek has its beginnings near Grand Coulee. As a usual rule East Foster Creek melts out and run-off starts about a week earlier than West Foster unless a hard rain starts them both at the same time.*"

Peak stream flows were recorded using peak crest-stage gauges on East Fork Foster Creek at Leahy (1959-1977), West Fork Creek near Bridgeport (1957-1977), East Fork Foster Creek Tributary near Bridgeport (1957-1977), (USGS, Washington Current Stream Flow Conditions, http://wa.water.usgs.gov/realtime/current.html.). Further analysis of historic annual flows need to be collected from USGS field offices. There are no current stream flow stations at Foster Creek.

Exotic and Opportunistic Species

Baby's breath has been found along entire mainstem Foster Creek, East Foster Creek, West Foster. Diffuse knapweed has been observed throughout the mainstem Foster Creek. Dalmatian toadflax has been observed in stretches of East and West Foster. There is an outbreak of saltceder on West Foster (Washington State Noxious Weed Control Board Map 1997).

Above the irrigation dam, Bob Steele, WDFW Fish Biologist, found one adult brown trout (18 inches) that had been planted by the Department of Fish and Wildlife.

Biological Process

There is an old beaver lodge and remnants of a ponded system a few miles downstream of Leahy junction on East Foster Creek. The beaver had to be removed to preserve the remaining woody riparian vegetation in this reach. The extent of beaver activity in the Foster Creek drainage and the effects of the reduction in beaver activity on water, sediment and nutrient storage is unknown.

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<u>Beebe</u>

The Beebe subwatershed contains approximately 34,410 acres. It includes tributaries to the Columbia River (Lake Entiat); Sheep Trough Draw, Hendricks Draw, Corral Creek also known as McNeil Canyon, Farnham Canyon, Greens Canyon, Browns Canyon, Corbaley Canyon (also known as Pine Canyon)(RB) and the lower reach of McGinnis Canyon (LB).

Loss of Access to Spawning and Rearing Habitat

The lower reach of Corbaley Canyon, currently consisting mostly of large cobble and gravel, has been diverted through a man made channel. In the summer months the creek goes subsurface in this lower reach (RM 0 to 3). Fish passage has been blocked through this reach except during high flow events. The last time there were surface flows through this reach was in 1996 due to high snowfall in the upper elevations of the watershed (Waterville Plateau). When flows are present, an annual group of juvenile rainbow may undergo the smolting process, moving-out of the tributary and into the Columbia River system. It is thought Corbaley Canyon used to sustain year-round flows on a more often than presently (TAG, 10-30-00; TAG 11-21-00).

Floodplains and Channel Conditions

The floodplain consists mostly of river wash that has been moved to form a more permanent channel. There is disconnected hydraulic continuity (TAG 11-21-00).

The channel at the lower reach (RM 0.0-RM 2.0) consists of river wash and has been diverted to create a move permanent channel. The middle reach (RM 2.0-RM 6.0) has a well defined channel, some significant pools, and a dense riparian canopy (TAG 10-30-00; TAG 11-21-00).

Riparian Conditions

There is dense riparian stand at the mouth of Corbaley Canyon up to the SR 97 channel crossing (RM 0.25). There is little riparian habitat from RM 0.25 - 2.0, and brushy riparian habitat from RM 2.0 - 6.0, consisting of willow, reed canary grass, service berry, pine, wild rose, and other species (TAG 10-30-00; TAG 11-21-00).

Water Quality

No information available

Water Quantity

Corbaley Canyon is spring feed and goes dry/ subsurface at the lower reach (TAG 10-30-00). Peak flows have not been recorded for Pine Canyon. Further analysis of historic annual flows need to be collected from USGS field offices. There is currently no stream flow monitoring on Corbaley Canyon Creek.

Exotic and Opportunistic Species

No other fish have been seen in Corbaley Canyon other than rainbow/steelhead trout (TAG 11-21-00).

Diffused knapweed, baby's breath, Dalmatian toadflax and reed canary grass have been found in Corbaley Canyon (Washington State Noxious Weed Control Board Map 1997; TAG 11-21-00).

Biological Process

There is no documented evidence of anadromy in Corbaley Canyon although it is thought that when flows are present through the lower reach, juveniles from the reproducing resident rainbow trout population may emigrate into the Columbia River, undergoing smoltification and migrating to the ocean. Adult steelhead may also possible migrate up into Corbaley Canyon when adequate stream flows are present in the lower reach, allowing steelhead to breed with resident rainbow trout. If this occurs, the steelhead carcasses would remain in the stream, contributing to the nutrient transfer. For more fish information see the *Fish Distribution and Status Chapter.*

It is assumed that beavers were historically active in Corbaley Canyon (TAG 11-21-00).

Literature Cited:

Washington State Noxious Weed Control Board. 1997. Noxious Weed Survey of Douglas County, Washington.

<u>Sand Canyon</u>

The Sand Canyon subwatershed contains approximately 2,900 acres (KCM 1995). It includes tributary to the Columbia River, Sand Canyon Creek. Sand Canyon Creek is a salmonid stream.

Loss of Access to Spawning and Rearing Habitat

There is a concrete diversion put in by the DOT at Sunset Highway (RM ± 0.25) that is an impassable barrier to fish. At the time of Bob Steele's survey in the early-1990's, fish were observed up to this barrier, however it is uncertain if fish presently can reach the barrier. Currently there is a thicket of golden willow growing horizontally across the stream and also a headcut in this lower reach stretch that may be impassable to fish (TAG 10-30-00; TAG 11-21-00).

Floodplains and Channel Conditions

Flooding in Sand Canyon, impacting an urban area, has been addressed in a Comprehensive Flood Hazard Management Plan in 1995. Flooding is typically caused by two types of storm events: summer thunderstorms and late winter-early spring rainstorms combined with snowmelt. Although both types of storms can cause extensive flooding, summer thunderstorms have resulted in the most damaging floods to the City of East Wenatchee (KCM 1995).

The upper portion of Sand Canyon consists primarily of wheat lands that lie fallow between crop rotations. Minimal vegetative cover during the fallow period results in soils being particularly susceptible to erosion. The canyon descends from the uplands to the terraces where urban areas and orchard lands are located. Sand Canyon also contains active and potential slide zones caused by oversteepened and undercut slopes. Because of the scarcity of drainage facilities below these canyons, floodwaters travel in streets and natural drainage depressions between the streets. Existing drainage culverts and pipe systems are rapidly filled and plugged with sediments during these runoff events, rendering them nonfunctional. The floodwaters, traveling toward the Columbia River, cause extensive erosion damage and fill the existing drainage systems with sediment (KCM 1995).

Sand Canyon Creek originates in dryland crop and rangeland areas and drains 2,900 acres (4.6 square miles). From the base of Badger Mountain foothills to RM 2.0 Sand Canyon Creek is naturally confined in a deep canyon with very little potential for overbank flows (KCM 1995). The stream corridor from RM 2.0 to RM 0.0 has been impacted by development in the East Wenatchee area. In some areas from RM 2.0-0.0 only an orchard or pavement provide the drainage way with no defined channel. Irrigation, agriculture, and lawns have increased the baseflow and the Wenatchee Reclamation District Irrigation Canal delivers a quantity of water directly to the stream at RM 0.50 from late March to October.

The lower reach (RM 0.0 - 0.25) has been channelized, intentionally moved with machinery and placed in its present channel. No pools over a foot in depth have been observed to date (Chuck Jones; TAG 11-21-00).

Floods within Sand Canyon are compounded by extreme soil erosion and sedimentation. Soils in the area are chiefly fine sands that are highly erodible, particularly on steep and mostly barren slopes. In undeveloped areas, erosion problems are relatively rare because rain infiltrates the highly permeable soils reducing the amount of surface water runoff. Most undeveloped areas also have natural vegetative cover, which helps strengthen the soil surface to reduce the transportation of sediment. <u>However, within developed areas, streets and other impermeable surfaces, large volumes of runoff can easily be produced that rapidly erode the barren soils along the road margins (few roads within East Wenatchee have curbs and gutters). see statements above under channel conditions</u> In addition to erosion problems in developed areas, a large amount of runoff and sediment is transported from bare soils in the agricultural areas immediately above East Wenatchee (KCM 1995).

There is very little cobble in Sand Canyon, mostly a sandy creek (TAG 11-21-00).

Riparian Conditions

Riparian vegetation is thick at the confluence of Sand Canyon, dominated by cottonwood (*Poplulus trichocarpa*), willow (*Salix spp*.), red osier dogwood (*Cornus stolonifera*), hawthorne (*Crataegus douglasii*), wild rose (*Rosa spp*.), snowberry (*Symphoricarpus albus*), and reed canary grass(*Phalaris arundinacea*). From the confluence upstream to RM 0.25, there are patches of shaded riparian habitat but this is limited where the stream passes through an orchard and trailer park. Riparian vegetation is patchy above RM 0.25.

Water Quality

Summer flows in Sand Canyon below RM 0.25 are sustained by irrigation water returns and water temperature remains cold in the summer time (TAG 10-30-00).

Water Quantity

Lower Sand Canyon conveys irrigation water and return flows on a seasonal basis (KCM 1995). Flows below the canal at RM 0.50 to RM 0.0 are an artifice of irrigation practices that maintain flows throughout the summer and brings summer flows up during rearing when otherwise the creek would be dry, making fish use in this lower reach dependent on irrigation flow. This is a rare stream where fish are being drawn in because of irrigation water. Turning off the irrigation water would have a detrimental effect (Bob Steele, TAG 10-30-00). Baseflows in the winter are likely to be a result of the irrigation water infiltration in the lower part of this watershed throughout the growing season. There have been no recorded peak stream flow records on Sand Canyon Creek. Further analysis of historic annual flows need to be collected from USGS field offices. There is currently no stream flow monitoring on Sand Canyon Creek.

Exotic and Opportunistic Species

No aquatic exotic species have been noted (TAG 11-21-00).

Diffuse knapweed and baby's breath have been observed in the lower reach of Sand Canyon (Washington State Noxious Weed Control Board Map 1997)

Biological Process

It can be assumed beavers were historically active in Sand Canyon (TAG 11-21-00).

Literature Cited:

KCM, Inc. 1995. Comprehensive flood hazard management plan, Draft Report. Douglas County Transportation and Land Services .

Washington State Noxious Weed Control Board. 1997. Noxious Weed Survey of Douglas County, Washington.

Rock Island

The Rock Island subwatershed contains approximately 139,055 acres (NRCS 1977; KCM 1995). It includes tributaries to the Columbia River: Rock Island Creek (tributaries to Rock Island Creek: Bevington Canyon (LB), Beaver Creek (RB)**).** Rock Island Creek is a salmonid stream.

Loss of Access to Spawning and Rearing Habitat

An upland spring at RM 0.75 maintains perennial flow from RM 0.75 to RM 0.0. There is no salmonid passage beyond this spring. The flow from RM 0.75 to RM 0.0 is shallow (TAG 10-30-00; TAG 11-21-00).

Floodplains and Channel Conditions

According to Lucy Keene, in 1948 there were four major cloudbursts and associated flooding. Cattle had to swim across Rock Island creek during the flood. Since this time there hasn't been enough water in Rock Island Creek to water cattle in the wintertime. In 1960 the Great Northern Railroad built lateral rock dikes to stop flooding over the railroad bridge but most of it has blown out over time (Lucy Keene).

Flooding in Rock Island Creek wiped out beaver dams and created a deep channel (Lucy Keene, TAG 10-30-00). Rock Island Creek throughout the entire reach, as the name implies, is extremely rocky.

Riparian Conditions

Currently there are groves of quaking aspen and cottonwoods at the mouth of Rock Island Creek. In 1887 when the Keene family settled at the mouth of Rock Island Creek, it was alive with groves of quaking aspens and cottonwoods (Lucy Keene). Today's stand is probably a remnant of what once was present. In the upper reaches, riparian habitat is in poor condition (TAG 11-21-00).

Water Quality

No information available.

Water Quantity

Flows in Rock Island Creek are dependent on two sources; spring snowmelt runoff and a spring system providing groundwater recharge into the channel.

The groundwater recharge (through spring upwelling) maintains flows year round. In the early 1960s, the channel would go dry so landowners (Keene's) dug in the channel bed to see if they could hit water. They dug until they hit underlying groundwater aquifer about 7-8 feet down. Fifteen inches of water came up and never has frozen indicating they hit an artesian well. The next year there was flooding again that completely filled in the excavated area of the creek bed with bedload material, but the well bubbled out of the ground again and has never quit running. This is the water you see today at the bottom of Rock Island Creek (Lucy Keene).

Rock Island flows high in the early spring carrying snowmelt. In some years when spring runoff is adequate, instream flows are continuous. Later, in the summer, flows go subsurface remaining totally dry during the summer and fall months upstream of the spring at approximate RM 0.5 to RM 0.75, with only pockets of pooled water in the channel on Badger Mountain approximate RM 8.

There are no peak stream flow records for Rock Island except for observation made by Lucy Keene in 1999 and 2000. "*In 1999 Rock Island Creek stopped running full length the third week in May until the next spring. There was water intermittently 2-3 miles above the spring. It was dry in-between these places. In the year 2000, the creek started running March 24th full length and stopped March 31. It ran again full length April 2nd to the April 18th but extremely muddy. There has been no water since then in that section*" (Lucy Keene, TAG 10-30-00). Further analysis of historic annual flows need to be collected from USGS field offices. There is currently no stream flow monitoring on Rock Island Creek.

Exotic and Opportunistic Species

There are no known aquatic exotic species (TAG 11-21-00).

Diffuse knapweed and baby's breath have been observed in the lower reach of Rock Island (Washington State Noxious Weed Control Board Map 1997).

Biological Process

Beavers were active historically on Lucy Keene's property 7-8 miles up Rock Island Creek. It was a great place for rainbow trout to live. Gradually, the beavers were trapped and floods came and wiped out the beaver dams (Lucy Keene, TAG 10-30-00).

Literature Cited:

KCM, Inc. 1995. Comprehensive flood hazard management plan, Draft Report. Douglas County Transportation and Land Services.

Watersheds Douglas County, Washington. 1977. Section I, FOTG General Resource Reference, Natural Resource Conservation Service, Waterville Field Office, Waterville, Washington.

Washington State Noxious Weed Control Board. 1997. Noxious Weed Survey of Douglas County, Washington.

Overview of Upper and Lower Moses Coulee Subwatersheds

The Moses Coulee is a deep, wide, flat-bottomed valley between Badger Mountain and Beezley Hills. The coulee is a former channel of the Columbia River, formed when the river was diverted from its present course by glacial dams during the late Pleistocene era. The coulee gradually descends as it extends southwesterly from northeast Douglas County to its end on the bank of the Columbia River (RM 447.9). The valley bottom ranges from one-half to three-fourths of a mile wide. Steep side slopes rise about 600 feet from the valley floor before leveling off in the upper plateau (KCM 1995).

Lower Moses Coulee

The Lower Moses Coulee subwatershed contains approximately 119,154 acres. It includes Moses Coulee, a tributary to the Columbia River. Moses Coulee is also referred to as McCarteney Creek or Douglas Creek. Other tributaries in the Lower Moses Coulee include Rattlesnake Creek (LB), Dry Coulee (RB), Airplane Canyon (RB), Skookumchuck Canyon (RB), Petrified Canyon (LB), Haungate (LB), Whiskey Dick Creek (RB), Sutherland Canyon, Straight Hollow (LB), Wood Gulch, and Francis Canyon (RB). Both salmon and steelhead are known to use the lower one-mile reach of Moses Coulee. Potentially, when adequately high spring flows are present, steelhead could migrate even further up Moses Coulee to one of its tributaries, Douglas Creek (RM 19.3) Douglas Creek is separately addressed in the Douglas Subwatershed.

Loss of Access to Spawning and Rearing Habitat

Flooding in 1989 may have caused the Moses Coulee to go subsurface thereby contributing to insufficient flow for salmon or steelhead (Katherine March, WDFW, pers. comm., 2000). Bob Steele sampled sections in the lower 19.3 miles of the Moses Coulee in the 1970s and at that time it flowed year around. Since then the reach has been scoured out and only runs water during spring runoff (Bob Steele, TAG 10-30-00). Dave Billingsley, a local landowner whose family homesteaded Moses Coulee, has stated that very seldom has he seen total continuity in flows in Moses Coulee Creek. Salmon have never been found upstream of the lower one mile of Moses Coulee Creek. Bob Steele attributes this to insufficient flows and high water temperatures.

There is the potential, given adequately high spring runoff flows, for steelhead to migrate up Moses Coulee Creek to Douglas Creek (RM 19.3).

Floodplains and Channel Conditions

The floodplains are and continue to be shaped by high flood events (TAG 10-30-00).

A Comprehensive Flood Hazard Management Plan was prepared for the Douglas County Land and Transportation Department to address recurring flooding problems in; the town of East Wenatchee and its vicinity, the Palisades area of the Moses Coulee, and the Jameson Lake area. The Palisades area is located around RM 15 of the Moses Coulee. Flooding within the Palisades area of Moses Coulee is primarily a result of a large snow pack melting over frozen ground (KCM 1995). A sudden rise in temperature results in the snow melting rapidly and then flowing downstream. Potential flood problems also occur when late fall rains saturate the surface soil and then freeze. The largest floods occur when climatic conditions cause a rapid and simultaneous runoff from all parts of the watershed (KCM 1995). In the Moses Coulee, floods occur when freezing temperatures during the night are followed by daily thawing. This results in a series of nightly peaks followed by lesser flows during the day. Usually, the earliest runoff is from the flat sagebrush lands, followed by runoff from the southwestern portion of Badger Mountain, and then by runoff from cultivated areas near Waterville (KCM 1995). Many of the floods, including the 1948 flood, occur as the result of "cloudbursts" in the watershed (Dave Billingsley).

Douglas Creek contributes the majority of flow volume to Moses Coulee during flood events (KCM, 1995). Occasionally, Rattlesnake Creek also contributes a relatively high percent of flow to Moses Coulee during flood events (KCM 1995). In 1989, snowmelt runoff from both areas combined to produce extreme flood conditions. Large quantities of silt and sand, washed from the upland wheat farms, and gravel and rock debris from the talus slopes in the canyon were carried downstream by the floodwaters. Douglas Creek and Rattlesnake Creek are relatively steep, transport streams, capable of delivering large quantities of water and debris to Moses Coulee, which is a low gradient valley bottom. Once exiting the naturally confining, steep canyon channels, these tributary streams can overflow their banks during flood events, spreading out over the farmland and Coulee bottom to depths of 1 to 3 feet. As water velocities drop, large quantities of silt and sand once carried along in the fast moving, confined flows are deposited on the Coulee floor, forming a low outwash delta at the confluence of Douglas Creek with Rattlesnake Creek. During severe floods, sediment deposits have exceeded 2 feet in depth over a large portion lands served by the Palisades Irrigation District (KCM 1995)

The Palisades is very isolated and dominated by rural agriculture with occasional farm homes. Approximately 55 homes are located in the Palisades area of Moses Coulee. Residents have been isolated for over one week at a time when floodwaters have completely innudated the valley bottom (KCM 1995).

Major floods occurred in Moses Coulee in 1938, 1948, 1957, 1960, 1973, and 1989 (KCM 1995). The Corps of Engineers records show 14 damaging floods from 1911 to 1948, an average of about one every two and one half years. One stream flow station was located in the Moses Coulee near the Palisades, 3 miles downstream from the Douglas Creek tributary, from 1951-1955. In March of 1951, the US Geological Survey (USGS) recorded a peak flow in the Moses Coulee near the Palisades at 1,990 cubic feet per second. Average annual flows recorded by the USGS at this station for the years 1953-1955 (fragmentary records) are below 30 cfs (USGS Annual Flow Data).

According to the *Sagebrush Flats Watershed Erosion Control Project* (Herring 1985), flooding in Douglas Creek has long been a problem for residents of the Palisades, with heavy flooding occurring in 1939 and 1948 and more recently in 1978 and 1982. Herring (1985) cites a 1978 report listing the 1948 flood as being the largest on record, having a discharge of 3,680 cubic feet per second. Herring (1985) estimates the recurrence interval as being every ten years.

Moses Coulee Creek, through the lower five miles (not including the mouth) of the Moses Coulee has been heavily manipulated. The main channel in through the Palisades (RM 15) area has been dredged to clear sediment that has washed down from upper reaches and tributaries (Katherine March, WDFW, pers. comm., 2000). Sections of this same reach have been riprapped (TAG 11-21-00).

- Streambed Sediment Conditions

  A study was conducted on the Sagebrush Flats Watershed in 1985 encompassing both the lower and upper Moses Coulee (Herring 1985). Reports cited in Herring (1985) indicate that water and wind erosion have occurred in the Sagebrush Flats Watershed for a number of years. A report issued after the flood of 1939 states that 19% of the Moses Coulee Watershed, of which Sagebrush Flats is a part, had lost from 25% to 75% of the original topsoil (Herring 1985). Studies on this watershed focused on concentrated flow, rill erosion, and runoff. The results of this study are listed below.

- Concentrated Flow

  Soil loss due to concentrated flow was measured in fifteen drainages covering 4 acres of cropland. The drainage areas had been seeded the previous fall, and the measured soil loss occurred during snowmelt in the spring. The total ton of soil loss was cut in half to represent the soil loss for one year of a two year cropping rotation system. For the 4 acres included in the study, 678.22 tons/year of soil loss was recorded. Rangeland was not included in this inventory (Herring 1985). This is not representative of the entire watershed, although this measurement does indicate that more soil loss is occurring than predicted by the Universal Soil Loss Equation (USLE) alone (Herring 1985). The USLE was introduced in 1959 by the U.S. Department of Agriculture as a tool to predict the average rate of soil erosion for each various alternative combinations of cropping systems, management techniques, and erosion control practices on any particular site.

- Rill Erosion

  Cropland soil loss due to rill erosion was measured on nine sites. The average soil loss for the nine sites was 10.0 tons/acre. As done with concentrated flow measurements, the loss from rill erosion was cut in half to represent the two-year cropping rotation system. This figure is twice the loss predicted by the Universal Soil Loss Equation (USLE). This may be due in part to the slope steepness, the small number of sites where rill erosion was measured (few areas of rill erosion were observed), and the fact that the number of acres where rill erosion occurred was also very small. Due to these differences it is probable that the Universal Soil Loss Equation (USLE) prediction of soil loss is somewhat more representative of what is actually occurring than the rill erosion measurements, or predictions given by the equation are not completely accurate and that more soil loss should be expected than the equation predicts (Herring 1985).

- Runoff

  Measurement of Sediment in Spring Runoff in the spring of 1985 was unusual in that the temperatures warmed slowly, the entire soil profile thawed, and the water was able to soak into soil layers. Many years a sudden warming trend causes the snow to melt rapidly while the ground beneath remains frozen. If a sufficient amount of precipitation or runoff occurs while the ground is frozen, serious soil erosion from the movement and deposition of large quantities of topsoil may result. There was little runoff the spring of 1985 and samples were taken of the runoff that did occur.

  One runoff site with a discharge rate of 0.134 cubic feet per second and carrying approximately half a ton of soil per hour was observed on a road. Once across the road, the water flowed northwest through a field. It did not enter one of the main drainages of this part of the watershed. Instead it spread out over the field as the slope leveled off. When checked two days later, no runoff was occurring at these locations.

  The samples that were collected are not representative of the entire watershed, as most drainages had no runoff. Nor do they represent subwatersheds within the larger one, for most of the samples were not collected at places where subwatersheds empty. It is also possible, due to different soil conditions, types of precipitation, and amount of ground cover, that runoff collected after storm events during other times of the year might not contain comparable amounts of sediment. Because of these factors, no estimates of total runoff and sediment content for the watershed, or its subwatersheds, were made. The data collected will be used to establish a baseline and will be compared to runoff samples collected in future years (Herring 1985).

  Both general and specific types of erosion occur in the Sagebrush Flats Watershed. These soil losses affect the quality of water within the watershed and at locations downstream. As a whole, the predicted annual soil loss is greater than the amount the soils can tolerate. (Herring 1985)

> It is difficult to draw long-term implications from a one-year study. The inventory findings do show, however, that large quantities of soil are being lost from the cropland areas of the watershed. It is highly probability that this soil is entering watershed stream channels and reducing water quality in the watershed and drainages downstream (Herring 1985).

Riparian Conditions

Dominating the valley floor of the Moses Coulee are large fields of wheat and alfalfa interspersed with small orchards and pastureland. Agriculture use has replaced most of the native sagebrush steppe vegetation (KCM 1995) and riparian vegetation.

Water Quality

During storm events and spring snowmelt, major erosion problems occur within the Sagebrush Flats Watershed. The soil loss results in decreased productivity of the cropland as well as lowering water quality within the watershed and the drainages downstream. Sagebrush Flats drains into Moses Coulee approximately seventeen miles upstream from the Columbia River. When there is intense rainfall or sudden snowmelt runoff from Sagebrush Flats it has a detrimental effect on the water quality of the Moses Coulee (Herring 1985).

Water Quantity

According to Bob Steele, the upper reaches of Moses Coulee Creek above the Palisades generally contain water year-round but frequently in standing pools. Flows in the lower reaches are extensively used for irrigation. The Palisades Irrigation District operates out of Moses Coulee. There are two diversions located on Douglas Creek within 0.25 miles of where the creek enters the Coulee (Steve King, Palisades Irrigation District, pers. comm., 2001). During dry summer months, the lower reach dewaters (Gaines, 1987). Katherine March (biologist, WDFW) and TAG 10-30-2000 participants have observed flows in the lower reach being entirely diverted. However, instream flows may resume during summer thundershowers and occasionally high spring flows will make it to the Columbia River (T. Jackson and S. Jackson 1994; Katherine March, WDFW, TAG 10-30-00).

Bob Steele sampled sections in the lower 19.3 miles of Moses Coulee in the 1970s and at that time it flowed year-round. Since then the reach has been scoured out and only flows during spring runoff (Bob Steele, TAG 10-30-00). Dave Billingsley, a local landowner whose family homesteaded Moses Coulee, has stated that very seldom has he seen total continuity in flows in Moses Coulee Creek. Salmon have never been found upstream of the lower one mile of Moses Coulee Creek. Bob Steele attributes this to insufficient flows and high water temperatures. There is the potential, given adequately high spring runoff flows for steelhead to make it upstream to the natural falls on the tributary to the Moses Coulee, Douglas Creek (Bob Steele, TAG 10-30-00).

Peak flow in the Moses Coulee has been record at Waterville (1954-1973) and at Douglas (1955-1976) Moses Coulee near the Palisades (titled Douglas Creek at Palisades) (1951-1955) (nearest US Post Offices at the time of survey) (USGS: Washington Current Stream Flow Conditions, http://wa.water.usgs.gov/realtime/current.html.) Exact points of these monitoring stations can be obtained from the USGS field office in Spokane. Annual flows have not been recorded. There are no current USGS monitoring stations.

Exotic and Opportunistic Species

No exotic or opportunistic species have been observed in Moses Coulee, but there have been no survey efforts for exotic or opportunistic aquatic animal species.

Baby's breath is found though out the Moses Coulee. Dalmatian toadflax, perennial pepperweed, diffuse knapweed are found in the lower reach of the Moses Coulee. Russian knapweed, kochia are found in the middle reach up to Douglas Creek (Washington State Noxious Weed Control Board Map 1997).

Biological Process

Historic beaver activity (TAG 11-21-00).

Literature Cited:

Gaines, W.L. 1987. Secondary production of benthic insects in three cold-desert streams. Battelle, Pacific Northwest Laboratory, Richland, WA.

Herring, J. 1985. Sagebrush Flats watershed erosion control project, Phase 1 Final Report, DOE/ REF. 39 Grant # WFG-84-046, South Douglas Conservation District. 42 p.

Jackson, T. B. and S. Y. Jackson. January 1994. Comparative tagging study in a resident wild trout stream (1992). Washington Department of Fish and Wildlife, Olympia, WA.

KCM, Inc. 1995. Comprehensive flood hazard management plan, Draft Report. Douglas County Transportation and Land Services.

Washington State Noxious Weed Control Board. 1997. Noxious Weed Survey of Douglas County, Washington.

Upper Moses Coulee

The Upper Moses Coulee subwatershed contains approximately 169, 990 acres. It includes the McCartney Creek drainage, a tributary to Moses Coulee. Tributaries to McCartney Creek include; Dutch Henry Draw (RB), Sulfur Canyon (LB), Amour Draw (RB), Coyote Canyon (LB).

Access to Spawning and Rearing Habitat

No information available.

Floodplains and Channel Conditions

No information available.

Riparian Conditions

No information available

Water Quality

No information available.

Water Quantity

Peak stream flow has been record at Rattlesnake Creek Tributary near Soap Lake (1959-1977) (USGS: Washington Current Stream Flow Conditions http://wa.water.usgs.gov/realtime/current.html.). Further information on historic annual flows needs to be obtained from USGS Spokane Field Office. Currently, there are no stream flow monitoring stations in the Upper Moses Coulee Subwatershed.

Exotic and Opportunistic Species

Diffuse knapweed, kochia, baby's breath, Dalmatian toadflax, and Russian knapweed have been observed (Washington State Noxious Weed Control Board Map 1997).

Biological Process

No information available

Literature Cited:

Washington State Noxious Weed Control Board. 1997. Noxious Weed Survey of Douglas County, Washington.

<u>Douglas Creek</u>

The Douglas Creek subwatershed contains approximately 131,852 acres. It includes Douglas Creek and tributaries to Douglas Creek: Kummer Draw (LB), Ruud Canyon (RB), Paine Creek (RB), Titchenal Canyon (RB), Duffy Creek (RB), Slack Canyon (LB), Mohr Canyon (LB), and Pegg Canyon (LB).

Loss of Access to Spawning and Rearing Habitat

There is a the potential, given adequately high spring runoff flows, for steelhead trout to migrate upstream through Moses Coulee Creek and enter Douglas Creek (RM 19.3) continuing upstream to the natural falls barriers. The falls represents the upper-most extent of potential anadromous fish passage in Douglas Creek, however, the upper reaches are very productive and large numbers of wild resident rainbow trout thrive there (Jackson, T. B. and S. Y. Jackson 1992). Bob Steele (fish biologist, WDFW) found a 22" mature resident rainbow trout (not a steelhead) in a lower pool in the canyon (1998). According to Steele, the rainbow trout in Douglas Creek are native, adapted to warmer temperatures of the watershed. Although WDFW has stocked rainbow trout in Douglas Creek in the past, Steele does not think hatchery fish would have persisted given the warm water temperatures and typically low survival rate of hatchery fish in the wild (Bob Steele, TAG 10-30-00).

Prior to 1998, there was an irrigation dam on Douglas Creek at approximately RM 1.0, downstream of the natural falls. Bob Steele surveyed this reach in 1998 and found the dam had blown out leaving a hole in it. Steele also identified juvenile rainbow trout both upstream and downstream of the now passable diversion. He interpreted this to mean that given adequately high spring flows, migrating adult steelhead have the potential to access as far upstream into the Moses Coulee drainage as Douglas Creek (RM 19.3), including up to and upstream of the concrete plug at RM 1.0. This presents the potential for adult steelhead to breed with the native resident rainbow population in Douglas Creek (Bob Steele, TAG 10-30-00).

Floodplains and Channel Conditions

On March 11, 1989, a high, intense flood occurred in Douglas Creek. There have been many similar flood events in the past and this probably is the main channel development mechanism at work in this area (Isaacson 1989). The extent to which human land use activities in the subwatershed have exacerbated to intensity and frequency of flooding events is unknown. According to the *Sagebrush Flats Watershed Erosion Control Project* (Herring, 1985), flooding in Douglas Creek has long been a problem. Heavy flooding occurred in 1939 and 1948 and more recently in 1978 and 1982. Herring (1985) cites a 1978 report listing the 1948 flood as being the largest on record, having a discharge of 3,680 cubic feet per second. It is estimated the recurrence interval is every ten years (Herring 1985).

Douglas Creek contributes the majority of flow volume to Moses Coulee during flood events ((KCM 1995). Occasionally, Rattlesnake Creek also contributes a relatively high percent of flow to Moses Coulee during flood events (KCM 1995). In 1989, snowmelt runoff from both areas combined to produce extreme flood conditions. Large quantities of silt and sand, washed from the upland wheat farms, and gravel and rock debris from the talus slopes in the canyon were carried downstream by the floodwaters. Douglas Creek and Rattlesnake Creek are relatively steep, transport streams, capable of delivering large quantities of water and debris to Moses Coulee, which is a low gradient valley bottom. Once exiting the naturally confining, steep canyon channels, these tributary streams can overflow their banks during flood events, spreading out over the farmland and Coulee bottom to depths of 1 to 3 feet. As water velocities drop, large quantities of silt and sand once carried along in the fast moving, confined flows are deposited on the coulee floor, forming a low outwash delta at the confluence of Douglas Creek with Rattlesnake Creek. During severe floods, sediment deposits have exceeded 2 feet in depth over a large portion lands served by the Palisades Irrigation District (KCM 1995). Major floods occurred in Moses Coulee in 1938, 1948, 1957, 1960, 1973, and 1989 (KCM, 1995). The Corps of Engineers records show 14 damaging floods from 1911 to 1948, an average of about one every two and one half years. Approximate flow quantities in Douglas Creek near Palisades for three major floods are listed below (Johnson 1974):

Date:	Flood Flow CFS:
June, 1948	3,680
March, 1951	1,990
Feb, 1957	2,600

Source: Columbia-North Pacific Comprehensive Framework Study (Johnson 1974)

The topography of the watershed varies from nearly level uplands in the northern portion to steep canyon breaks in the southern part (Isaacson 1989).

Riparian Conditions

The northern portion is primarily cropland with the southern portion being a mixture of crop, range, and forested land (Isaacson 1989).

Water Quality

Water quality was tested for one year on a monthly basis. Groundwater sampling consisted of collecting two samples, one during September 1988 and one during June 1989. Nine out of 42 wells were over the state limit for nitrate nitrogen. In 1989, the samples were taken again with the similar results. Eleven wells were tested for coliform bacteria and resulted in seven of these over the WA State standards (Isaacson 1989). The one-year sampling on a monthly basis is adequate for pointing out problems, but is not a standard to determine the extent of the problem or cause of the problem. It is impossible to draw conclusions between farming practices, on-site conservation practices, and water quality from this study. The winter flood of March 1989 was the controlling factor that dominated the water quality. Access and manpower were not available to collect data during the floods so the most important data of the study period was lost (Isaacson 1989).

Groundwater sampling revealed serious problems. A 1989 study was designed to sample 12 surface water sites on a monthly basis, and to monitor ground water in wells used for domestic water supplies. High nitrates and phosphates were found in the waters of the Douglas Creek subwatershed. It is known that there is a high percentage of land in the Douglas Creek subwatershed receiving applications of fertilizer, which contain nitrates and phosphates. Compounding this problem is the arid climate of the upper Douglas Creek subwatershed that does not allow for adequate dilution of nitrate and phosphate levels until lower in the subwatershed. The dilution that takes place in the lower reaches of Douglas Creek result in water in lower Douglas Creek being of a much higher quality than water within the rest of the subwatershed (Isaacson 1989).

Seven surface water quality stations were located in Douglas Creek. The rest were located in tributaries to Douglas Creek: Kummer Draw, Paine Creek, Duffy Creek, and Pegg Canyon.

Habitat quality is affected by runoff from surrounding agricultural lands and by heavy livestock use in some areas (Isaacson 1989).

Water Quantity

Douglas Creek is a small, mostly spring-fed stream. The upper reaches of Moses Coulee Creek above Palisades contain water year around, however flows in the lower reaches are extensively used for irrigation. The Palisades Irrigation District operates out of Moses Coulee. There are two diversions located on Douglas Creek within 0.25 miles of where the creek enters the Coulee (Steve King, Palisades Irrigation District, pers. comm., 2001). During dry summer months, the lower reach dewaters (Gaines 1987). Katherine March (biologist, WDFW) and TAG 10-30-00 participants have observed flows in the lower reaches being entirely diverted. However, instream flows may resume during summer thundershowers and occasionally high spring flows will make it to the Columbia River (T. Jackson and S. Jackson, WDFW, 1-2, 1994; Katherine March, WDFW, TAG 10-30-00).

Peak Stream flow was monitored by the USGS on Douglas Creek at Alstown (1948-1968) (RM 13.2), and annual flow was monitored on Douglas Creek near Palisades (1949-1952) (USGS: Washington Current Stream Flow Conditions) http://wa.water.usgs.gov/realtime/current.html. There are currently no stream flow monitoring stations on Douglas Creek.

Exotic and Opportunistic Species

Baby's breath has been observed in lower reach of Douglas Creek. In the upper reach south of the town of Douglas, Russian knapweed has been observed. Dalmatian toadflax was observed near the town of Douglas (Washington State Noxious Weed Control Board Map 1997).

Biological Process

No information available.

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Washington State Noxious Weed Control Board. 1997. Noxious Weed Survey of Douglas County, Washington.

<u>Pine Canyon</u>

There is no known salmonid use in this watershed. The Pine Canyon subwatershed contains approximately 17,600 acres. It includes tributary to Corbaley Canyon/Pine Canyon: McGinnis Canyon. The boundaries for this subwatershed unit are unclear on the subwatershed map used in this report as developed by the Water Resources Council of the U.S. Department of Interior (NRCS 1977).

Access to Spawning and Rearing Habitat

No information available.

Floodplains and Channel Conditions

No information available.

Water Quality

No information available.

Water Quantity

No information available.

Exotic or Opportunistic Species

Dalmatian toadflax and baby's breath have been observed (Washington State Noxious Weed Control Board Map 1997).

Biological Processes

No information available.

Literature Cited*:*

Washington State Noxious Weed Control Board. 1997. Noxious Weed Survey of Douglas County, Washington.

<u>Farmer Area</u>

There is no known salmonid use in this watershed. The Farmer Area subwatershed contains approximately 39,389 acres and encompasses the tributary to the McCarteney Creek: Pine Canyon.

Loss of Access to Spawning and Rearing Habitat

No information available

Floodplains and Channel Conditions

No information available

Riparian Zone Conditions

No information available

Water Quality

No information available

Water Quantity

Peak stream flow has been recorded at Pine Canyon Tributary near Farmer (1960-1976), and McCarteney Creek Tributary near Farmer (1960-1976). (USGS: Washington Current Stream Flow Conditions, http://wa.water.usgs.gov/realtime/current.html.)

Exotic and Opportunistic Species

Baby's breath and Dalmatian toadflax have been observed (Washington State Noxious Weed Control Board Map 1997).

Biological Process

No information available

Literature Cited:

Washington State Noxious Weed Control Board. 1997. Noxious Weed Survey of Douglas County, Washington.

Jameson-Grimes Lake

Jameson-Grimes Lake has no natural continuity with any flowing, fish-bearing surface waters nor are there any anadromous salmonid species in this subwatershed. The Jameson-Grimes Lake subwatershed contains approximately 121,872 acres, encompassing McCarteney Creek, a tributary to Moses Coulee and tributaries to McCarteney Creek: Long Canyon (LB), Kester Draw (RB), Burton Draw (LB). Jameson-Grimes Lake is located in upper Moses Coulee.

Jameson Lake is the largest natural lake in Douglas County (except for reservoirs behind Columbia River dams) and currently has a surface elevation of 1,781 feet and a surface area of approximately 488 acres. The Lake is considered one of the principal fisheries in the state and a popular fishing destination.

Jameson Lake was formed by a terminal moraine at its southern boundary. The lake is in a natural depression that historically has not had an outlet. Since the early part of the 20th century the elevation of Jameson Lake has risen steadily and in 1989 it reached the elevation of the outlet sill on the south end of the lake (KCM 1995).

Loss of Access to Spawning and Rearing Habitat

Salmonid species are not present in this watershed.

Floodplains and Channel Conditions

A Comprehensive Flood Hazard Management Plan (KCM, 1995) was prepared to address recurring flooding problems around the town of East Wenatchee, the Palisades area of the Moses Coulee, and the Jameson Lake area. Jameson Lake is in a natural depression that historically has not had an outlet. The level of Jameson Lake has risen more than 40 feet over the past 60 years. At its peak in March, 1989 rapid snowmelt caused the lake level to rise 88 inches in approximately four days. Outflow from the lake began to drain down Moses Coulee. It caused extensive damage to the northern and southern access roads, the Wittig farm, the wildlife access, and resorts on both ends of the lake. As of early 1994, the lake level was about 20 inches below the elevation of the outlet sill (KCM 1995).

Severe silting and erosion occurs in Douglas Creek, Foster Creek and Jameson Lake watersheds. The heavy sediment yields found in these areas are caused either by snowmelt or rain erosion of surface soil when the underlying ground is frozen or by high intensity rainstorms in the summer months. Control measures taken in this Foster Creek and South Douglas Conservation Districts include construction of debris and silt retention basins and better farming practices. Farming practices such as planting of fields into CRP, leaving high residue levels on cultivated fields, direct annual spring seeding, terraces, sediment ponds, and the use of conservation buffers and are aimed at reducing the negative impact of cultivation on water quantity and water quality.

Riparian Conditions

Jameson Lake is located in an area dominated by dryland wheat farming and rangeland. It is in the upper end of Moses Coulee in a semi-arid sagebrush environment.

Water Quality

Historically, Jameson Lake has had severe algae and dissolved oxygen problems. Prior to the late 1960s, heavy algae blooms and high winds resulted in depleted oxygen levels and extensive fish kills. Each year heavy algae blooms develop during the summer on Jameson Lake. As blooms die and sink to the bottom of the lake, they decompose and consume oxygen. Hydrogen sulfide, which is very toxic to fish, is produced when decomposition forms anaerobic conditions. During the fall, surface and bottom lake temperatures become equal and rapid missing of the water column (turnover) by winds causes oxygen-deficient water to rise to the surface, resulting in fish kills. Turnover in most lakes occurs over a period of several weeks, causing no fish mortality, but at Jameson Lake very rapid turnovers are common due to strong north winds in the fall (KCM 1995).

A reconnaissance investigation of water quality in Douglas County lakes was performed in the 1970s as part of a statewide project. Two water quality samples (one near the surface and one at depth) were collected from 16 lakes, including Jameson Lake. A subsequent analysis of eutrophication in Washington lakes concludes that most lakes in Douglas County would be classified eutrophic based on high concentrations of the nutrient phosphorus. For example, Jameson Lake had a total phosphorous concentration of 56-micrograms/ liter in the epilimnion (i.e., shallow lake depths) and 160 micrograms/liter in the hypolimion (i.e., deep lake depths). The general threshold indicating excessive enrichment (i.e. eutrophic conditions) in lakes is 20-micrograms/ liter. Many small seasonal lakes and potholes also exist in Douglas County, most or all of them highly alkaline (i.e., high pH with high dissolved solids) (KCM 1995).

Water Quantity

No information available.

Exotic and Opportunistic Species

Dalmatian toadflax, diffuse knapweed, Russian knapweed, and baby's breath have been observed (Washington State Noxious Weed Control Board Map1997).

Biological Process

Prior to 1950, Jameson Lake was too shallow to support fish. In the early 1950s the lake level rose due to irrigation in the area, and the lake was stocked with fish by WDFW. From the early 1950s through 1965, the Department of Game (precursor to WDFW) reported severe fish kills during the fall. Frequency varied from 1 to 3 years apart with major kills occurring in years 1955, 57, 58, 62 and 65. The Game Department estimated between 25,000 to 40,000 fish were killed in the fall of 1962 (Johnson 1974).

Since 1965 no severe fish kills have occurred on the lake. The drop off in fish kills is attributed to relocation of a cattle-feeding area at the north shore of the lake in the late 1960s and better agricultural soil conservation practices. However, significant algae growth occurs each summer, and monitoring in the 1970s indicated eutrophic conditions (high levels of nutrients for algae). Algae growth is probably enhanced by agricultural and livestock runoff and possible wastewater seepage from resorts located on the lake (KCM 1995).

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KCM, Inc. 1995. Comprehensive flood hazard management plan, Draft Report. Douglas County Transportation and Land Services.

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Columbia River Shoreline on the WRIA 50 and WRIA 44 Bank

The portion of the Columbia River that serves as a boundary for WRIAs 50 and 44 consists of a series of reservoirs with water levels subject to hydroelectric facility operations. There is very little side channel and slough habitat associated with this controlled river however, high river water levels, groundwater recharge, and irrigation overflow provide moisture levels sufficient to foster a dense, lush shrub-grass understory and stands of cottonwoods and poplars along the shoreline. The predominate vegetation along the Columbia River and lower canyons is willow, cottonwood, and reed canary grass (KCM 1995).

DATA GAPS AND RECOMMENDATIONS

Data in the literature on habitat conditions in the watersheds is extremely limited. The lack of existing baseline data for such basic habitat attributes like instream flows, sedimentation and temperature, and the lack of analysis comparing the change in riparian, wetland, floodplain and upland habitats, limits this report to a reliance almost entirely on the professional expertise of the TAG and landowners as the best available science. As more data is collected and analysis conducted, the assessments of this TAG can be refined and new conclusions may be drawn. More data and analysis can lead to a greater accuracy in assessing the affects of habitat conditions on salmonid spawning and rearing use in the Foster and Moses Coulee Watersheds.

Data Gaps and Recommendations by Categories of Habitat Limiting Factors

Access to Spawning and Rearing Habitat:

Updated fish passage barrier inventory**:** It has been indicated on Foster Creek that a massive flood event deposited a gravel bar that may preclude access to habitat up to RM 1.5. With surveys last conducted in the 1970s, 1980s, and 1990s, an updated fish passage barrier survey needs to be conducted in all salmonid streams in WRIA 44 and 50 (Foster Creek, Corbaley Canyon, Sand Canyon, Rock Island Creek and the Moses Coulee).

Floodplains and Channel Conditions:

Collect baseline data**:** There are no comprehensive studies on WRIA 44 and 50 channel conditions on width, depth, substrate composition, pool and riffle frequency, pool types, and channel roughness on any watercourses.

Wetland inventory**:** There are no comprehensive studies showing wetland acreage or functions lost over time from natural and human causes. A detailed wetland inventory, including functional analysis, would help to identify areas for restoration, enhancement, and protection for fish.

Riparian Conditions:

Riparian habitat survey**:** There are at present no inventory of riparian habitat in WRIA 44 and 50. A Riparian Habitat Survey was conduced with limited riparian classification on Foster, Duffy and Douglas Creeks by Rex Crawford from the Department of Natural Resources (DNR) but data is not in a format to review or draw any conclusions.

Water Quality:

Stream-specific water temperature studies on lower reaches of anadromous streams**:** All streams within Douglas County are classified Class A waters (WAC 173-201A-120(6)), however no long-term water quality monitoring and data collection has been conducted on any streams in Douglas County (KCM, 1995, p. 2-12).

Water Quality Criteria for Class A Waters: Source WAC 173-201-045(2)©

Water quality shall meet or exceed the requirements for all or substantially all uses.

1. Fecal coliform organisms shall not exceed a geometric mean value of 100 organisms/ 100mL, with not more than 10 percent of samples exceeding 200 organisms/ 100mL.

2. Dissolved oxygen shall exceed 8 mg/L.

3. Total dissolved gas shall not exceed 110 percent of saturation at any point of sample collection.

4. Temperature shall not exceed 18.0° C. Temperature increases shall not exceed t= 29/(T+7). ("t" represents the change across the dilution zone, and "T" represents the highest existing temperature in this water classification outside of any dilution zone.) When natural conditions exceed 18.0° C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3° C, provided the temperature increase resulting from nonpoint source activities shall not exceed 2.8° C, and the maximum water temperature shall not exceed 18.3° C.

5. pH shall be with the range of 6.5 to 8.5 with a man-caused variation within a range of less than 0.5 units.

6. Turbidity shall not exceed 5 NTU over background turbidity when the background turbidity is 50 NTU or less, or have more than a 10 percent increase in turbidity when the background turbidity is more than 50 NTU.

7. Toxic, radioactive, or deleterious material concentrations shall be below those of public health significance, or which may cause acute or chronic toxic conditions to the aquatic biota, or which may adversely affect any water use.

8. Aesthetic values shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch or taste.

Collect baseline data: A more extensive water quality monitoring program (ground water and surface water) is desirable in order to determine the impact of farming practices, soil erosion, and other pollution sources on water quality.

Hydraulic analysis: The present soil survey of the area (Foster Creek) has proven inadequate to the needs of the kind of integrated management plan that needs to put into effect. The present survey (1981) is broad and general. A more detailed soil survey is being conducted, due in published form in late 2001, in order to understand and effectively relate the hydrology to potentials for supporting the required revegetation necessary to reduce soil erosion, and improve water quality and wildlife habitats (Thompson and Ressler 1988; Elyse Benson, NRCS, pers. comm., 2000). A hydraulic analysis is needed, focusing on those drainages in subwatersheds that are under heavy cultivation with high erosion rates.

Water Quantity:

Evaluation of instream flow and surface/ground water interactions: Studies are needed that would assist in the evaluation of instream flows as they relate to changes in wetland functions, floodplain functions, groundwater/surface water interactions, and upland vegetation changes in the watersheds. Stream gauges need to be installed to learn more about the instream flows in WRIA 44 and 50. Research on surface/ground water interactions and investigation into the opportunity for augmenting low instream flows is needed.

Further analysis of historic annual flows need to be collected from USGS field offices. Currently, there are no stream flow monitoring stations in WRIA 44 & WRIA 50 tributaries (http://wa.water.usgs.gov/realtime/current.html).

Recommendations for Future Data Collection

General presence/absence salmonid surveys: Conduct general presence/absence salmonid surveys on selected streams highlighted by the information provided so far by the TAG (Foster Creek, Corbaley Canyon, Moses Coulee, Sand Canyon, Rock Island). Salmonid distribution information is limited and based on existing professional knowledge and surveys in the 1970's, 1980's, and 1990's. Habitat conditions have changed and there is a need to conduct an updated salmonid survey.

Collect baseline data: Collect baseline data on known fish bearing streams for the following habitat parameters; fine sediment, temperature, and instream flows. Use commonly accepted survey protocols (i.e. Hankin and Reeves. 2000. Pacific Northwest Region US Forest Service Stream Inventory Handbook, Level I and II).

Collect data and analyze change over time: Studies are needed that collect data and analyze the change over time in riparian habitat, wetland habitat, floodplain function, sediment delivery and transport, temperature regimes, and groundwater/surface water interactions. Information generated by these studies would contribute to making more informed conclusions about the extent to which salmonid productivity is limited beyond natural conditions, by human-induced alterations to stream channels and riparian conditions. Historical information gathered from landowners can be used to conduct analyses of changes over time of riparian, floodplain and wetlands acreage and conditions, and uplands vegetation cover types, as they affect watershed hydrology.

Restoration Projects: Habitat restoration projects must be directed at the condition(s) causing the habitat degradation (causal mechanisms), not at its symptoms. Structural manipulations of the stream channel (such as boulder or log placements) should not be used unless those causal mechanisms cannot be corrected within a reasonable time. Attempts to restore habitat are likely to fail if structures are placed in the stream channel without addressing those activities that are causing the habitat degradation as local residents have observed on Foster Creek. To identify causal mechanisms prior to implementing any structural manipulation of the channel, an evaluation of the stream channel hydrology, geology and morphology (hydrogeomorphology) must first be conducted. Habitat restoration projects must be designed to conform to natural channel processes when possible. Potential impacts from habitat restoration projects that do not support natural channel processes must be fully understood prior to implementation. For example, during high flows, rehabilitating structures are likely to blow out and it would be senseless to repair an artificial habitat after every flood event. Local resident on Foster Creek, Jo Miller, remarks, " *Nothing has been studied since 1989. This is the best data we have but only shows one point in time. This is a whole lot of money to rehabilitate the creek from every time it floods it happens every year. Are we going to have to support this habitat from here until ever and ever?"*

ASSESSMENT OF HABITAT LIMITING FACTORS

Table 2 provides a rating of habitat factors by stream or stream reach. The table only includes streams where salmon, rainbow/ steelhead, or bull trout are known to occur. Habitat factors rated coincide with the habitat limiting factors categories presented in the *Habitat Limiting Factors by Subwatershed* chapter of this report.

The information upon which the assessment is based was derived from published sources and the combined professional knowledge of the TAG. Therefore, each rating incorporates how one or more technical expert judged the quality of habitat at various locations based on available information. The assessment was completed over a 3-hour meeting on November 21, 2000. During the meeting, the participants assigned a rating of "Good" (Properly Functioning), "Fair" (At Risk) or "Poor" (Not Properly Functioning) using the criteria provided in the Salmonid Habitat Condition Rating Standards for Identifying Limiting Factors in the Foster and Moses Coulee Watersheds" (Appendix C). The number "1" assigned to the rating indicates quantitative studies or published reports exist to support the rating. The number "2" assigned to the rating indicates the knowledge of biologists and landowners was used to rate the condition and data analysis, data, or published reports were not available.

Habitat ratings provided in the assessment table correspond to habitat conditions identified by habitat factor in the *Habitat Limiting Factors by Subwatershed* chapter of the report.

The assessment table shows where field biologists have been and what they have seen or studied. Where "DG" (data gap) appears in the table, there was so little information available on the habitat condition (published or professional knowledge) that the TAG did not feel confident making even a qualitative determination of condition for the habitat factor. The absence of a stream on the list does not necessarily mean salmon, rainbow/steelhead or bull trout do not occur in the steam or imply that the stream is in good health. Streams may not be listed because they have not been documented to support salmon, rainbow/ steelhead, or bull trout nor surveyed for stream health conditions. Because 88% of the land in WRIA 44 and 50 is privately owned, few studies have been conducted. No studies have been conducted on salmon, rainbow/ steelhead, or bull trout. This is usually the case for stream reaches not on federal land. Other streams may show more impacts because they are easily accessible or have been the focus of more scientific study.

Table 2. Assessment of habitat conditions limiting salmonid performance in WRIA 44 and 50

Stream Name	WRIA Index	Access to Spawning and Rearing Habitat	Floodplains AND Channel Conditions	Riparian Condition	Water Quality	Water Quantity	Exotic and Opportunistic Species	Biological Processes
Foster Creek	50.0065							
RM 0.0-1.5		**P2**	**P2**	**P2**	**DG**	**F2**	**DG**	**DG**
RM 1.5 to upper extent (East, West, Middle Foster)		**N/A**	**P2**	**F2**	**DG**	**F2**	**DG**	**DG**
Corbaley Canyon (Pine Canyon)	44.0779							
RM 0.0-6 (horseshoe)		**P2**	**P2**	**P2**	**DG**	**P2**	**DG**	**DG**
RM 2-6		**P2**	**P2**	**F2**	**DG**	**F2**	**DG**	**DG**
RM 6 to upper extent		**N/A**	**DG**	**F2**	**DG**	**DG**	**DG**	**DG**
Sand Canyon	44.0756							
RM 0.0- 0.25		**P2**	**P2**	**F2**	**DG**	**F2* Irrigation Return**	**DG**	**DG**
RM 0.25 to upper extent		**P2**	**P2**	**P2**	**DG**	**P2**	**DG**	**DG**

Table 2. Assessment of habitat conditions limiting salmonid performance in WRIA 44 and 50

Stream Name	WRIA Index	Access to Spawning and Rearing Habitat	Floodplains AND Channel Conditions	Riparian Condition	Water Quality	Water Quantity	Exotic and Opportunistic Species	Biological Processes
Rock Island Creek	44.0630							
RM 0.0-0.75 (spring upwelling system)		**P2**	**P2**	**F2**	**DG**	**F2**	**DG**	**DG**
RM 0.75- upper extent		**N/A**	**P2**	**P2**	**DG**	**P2**	**DG**	**DG**
Moses Coulee	44.002							
RM 0.0-19.3 (outlet of Douglas Creek)		**P2**	**P2**	**P2**	**DG**	**P2**	**DG**	**DG**
Douglas Creek		**N/A**	**F2**	**F2**	**DG**	**G2**	**DG**	**DG**
RM 19.3 to upper extent of Moses Coulee		**N/A**	**P2**	**P2**	**DG**	**P2**	**DG**	**DG**

P= Average habitat condition considered to be poor (Not Properly Functioning)
F= Average habitat condition considered to be fair (At Risk)
G= Average habitat condition considered to be good (Properly Functioning)

1= Quantitative studies or published reports documenting habitat condition
2= Professional knowledge of the TAG members

DG= Data Gap; the stream or reach has not been surveyed, visited by members of the TAG, or so little is available that the TAG did not feel qualified rating the condition.
N/A= Not Applicable

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GLOSSARY

303 (d) List: The federal Clean Water Act requires states to maintain a list of stream segments that do not meet water quality standards. The list is called the 303(d) list because of the section of the Clean Water Act that makes the requirement.

Adaptive management: Monitoring or assessing the progress toward meeting objectives and incorporating what is learned into future management plans.

Adfluvial: Migratory between lakes and rivers or streams or, life history strategy in which adult fish spawn and juveniles subsequently rear in streams but migrate to lakes for feeding as subadults and adults. Compare fluvial.

Administratively Withdrawn Areas: A land management designation for federally-administered lands within the range of the northern spotted owl (USFS and BLM 1994). Administratively Withdrawn Areas are identified in current Forest and District Plans or draft plan preferred alternatives and include recreation and visual areas, back county, and other areas where management emphasis precludes scheduled timber harvest.

Aggradation: The geologic process of filling and raising the level of the streambed or floodplain by deposition of material eroded and transported from other areas.

Alevins (also sac fry or yolk-sac fry): Larval salmonid that has hatched but has not fully absorbed its yolk sac, and generally has not yet emerged from the spawning gravel. Absorption of the yolk sac, the alevin's initial energy source, occurs as the larva develops its mouth, digestive tract, and excretory organs and otherwise prepares to feed on natural prey.

Alluvial: Deposited by running water.

Alluvial fan: A relatively flat to gently sloping landform composed of predominantly coarse grained soils, shaped like an open fan or a segment of a cone, deposited by a stream where it flows from a mountain valley onto a plain or broader valley, or wherever the stream gradient suddenly decreases. Alluvial fans typically contain several to many unconfined, distributary channels that migrate back and forth across the fan over time. This distribution of flow across several stream channels provide for less erosive water velocities, maintaining and creating suitable rearing salmonid habitat over a wide range in flows. This landform has high subsurface water storage capacity. They frequently adjoin terraces or floodplains.

Anadromous fish: Species that are hatched in freshwater mature in saltwater, and return to freshwater to spawn.

Anchor ice: Forms along the channel bottom form the accumulation of frazil ice particles on the rough surfaces of coarse bottom sediments and on the lee sides of pebble, cobbles, and boulders.

Aquifer:

1. A subsurface layer of rock permeable by water. Although gravel, sand sandstone and limestone are the best conveyors of water, the bulk of the earth's rock is composed of clay, shale and crystalline.

2. A saturated permeable material (often sand, gravel, sandstone or limestone) that contains or carries groundwater.

3. An underground, water-bearing layer of earth, porous rock, sand, or gravel, through which water can seep or be held in natural storage. Aquifers generally hold sufficient water to be used as a water supply.

Basin: The area of land that drains water, sediment and dissolved materials to a common point along a stream channel.

Basin flow: Portion of stream discharge derived from such natural storage sources as groundwater, large lakes, and swamps but does not include direct runoff or flow from stream regulation, water diversion, or other human activities.

Bioengineering: Combining structural, biological, and ecological concepts to construct living structures for erosion, sediment, or flood control.

Biological Diversity (biodiversity): Variety and variability among living organisms and the ecological complexes in which they occur; encompasses different ecosystems, species, and genes.

Biotic Integrity: Capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region; a system's ability to generate and maintain adaptive biotic elements through natural evolutionary processes.

Braided stream: Stream that forms an interlacing network of branching and recombining channels separated by branch islands or channel bars.

Buffer: An area of intact vegetation maintained between human activities and a particular natural feature, such as a stream. The buffer reduces potential negative impacts by providing an area around the feature that is unaffected by this activity.

Capacity: the amount of available habitat for a specific species or lifestage within a given area. Capacity is a density-dependent measure of habitat quantity.

Carrying capacity: Maximum average number or biomass of organisms that can be sustained in a habitat over the long term. Usually refers to a particular species, but can be applied to more than one.

Channelization: Straightening the meanders of a river; often accompanied by placing riprap or concrete along banks to stabilize the system.

Channelized stream: A stream that has been straightened, runs through pipes or revetments, or is otherwise artificially altered from its natural, meandering course.

Channel Migration Zone: lateral movement of channel leads to a sequence of events through time where terraces are formed and new floodplain areas are defined.

Channel Stability: Measure of the resistance of a stream to erosion that determines how well a stream will adjust and recover from changes in flow or sediment transport.

Check dams: Series of small dams placed in gullies or small streams in an effort to control erosion. Commonly built during the 1900s.

Confinement: When a channel is fixed in a specific location restricting its pattern of channel erosion and migration

Confluence: the flowing together of two or more streams, or the combined stream formed by the conjunction.

Congressionally Reserved Areas: A land management designation for federally-administered lands within the range of the northern spotted owl (USFS and BLM 1994). These areas include Wildernesses, Wild and Scenic Rivers, National Monuments, as well as other federal lands not administered by the Forest Service or BLM.

Connectivity: Unbroken linkages in a landscape, typified by streams and riparian areas.

Constriction: The narrowing of a channel that impedes the downstream movement of water or debris, as in a small culvert crossing.

Critical Stock: A stock of fish experiencing production levels that are so low that permanent damage to the stock is likely or has already occurred.

Depressed Stock: A stock of fish whose production is below expected levels based on available habitat and natural variations in survival levels, but above the level where permanent damage to the stock is likely.

Debris torrent: A type of landslide characterized by water-charged, predominantly coarse grained soil and rock fragments, and sometimes large organic material, flowing rapidly down a pre-existing channel.

Degradation: The lowering of the streambed or widening of the stream channel by erosion.

Deposition: The settlement of material out of the water column and onto the streambed.

Distributaries: A river branch flowing away from the main stream.

Diversity: Variation that occurs in plant and animal taxa (i.e., species composition), habitats, or ecosystems. See *species richness.*

Ecological restoration: Involves replacing lost or damaged biological elements (populations, species) and reestablishing ecological processes (dispersal, succession) at historical rates.

Ecosystem: Biological community together with the chemical and physical environment with which it interacts.

Ecosystem management: Management that integrates ecological relationships with sociopolitical values toward the general goal of protecting or returning ecosystem integrity over the long term.

Emigration: to leave a place

Endangered Species Act: A 1973 Act of Congress that mandated the protection and restoration of endangered and threatened species of fish, wildlife and plants.

Endangered Species: Any species which is in danger of extinction throughout all, or a significant portion of its range, other than a species of the Class Insecta, as determined by the Secretary to constitute a pest.

Escapement: Those fish that have survived all fisheries and will make up a spawning population.

Estuarine: Of, or relating to, or formed in an estuary.

Estuary: A partly enclosed coastal body of water that has free connection to open sea, and within which seawater is measurably diluted by fresh river water.

Eutrophic: Pertaining to a lake or other body of water rich in dissolved nutrients, photosynthetically productive, and often deficient in oxygen during warm periods. Compare *oligotrophic.*

Evolutionary Significant Unit (ESU): A definition of a species used by National Marine Fisheries Service (NMFS) in administering the Endangered Species Act. An ESU is a population (or group of populations) that is reproductively isolated from other conspecific population units, and (2) represents an important component in the evolutionary legacy of the species.

Extirpation: The elimination of a species from a particular local area.

Flood: A rising and overflowing of a body of water especially onto normally dry land.

Floodplain: The low-lying, topographically flat area adjacent to a stream channel which is regularly flooded by stream water on a periodic basis and which shows evidence of the action of flowing water, such as active or inactive flood channels, recent fluvial soils, rafted debris or tree scarring. It varies in width depending on size of river, relative rates of downcutting and resistance of the bedrock in the valley walls.

Flow regime: Characteristics of stream discharge over time. Natural flow regime is the regime that occurred historically.

Fluvial: Of or pertaining to, or living in streams or rivers; also, organisms that migrate between main rivers and tributaries. Compare *adfluvial*.

Frazil ice: Thin particles of ice suspended in the water. Produced where extensive channel ice is formed and the freezing supercools the stream water producing nuclei of "frazil ice" particles.

Genetic Diversity Unit (GDU) is defined as: A group of genetically similar stocks that is genetically distinct from other such groups. The stocks typically exhibit similar life histories and occupy ecologically, geographically and geologically similar habitats. A GDU may consist of a single stock

Geomorphology: Study of the form and origins of surface features of the Earth.

Glacial Outwash/Glacial Fluvial Outwash: Nearly level terraces and floodplains in large valley bottoms. Slope is generally less than 10%. The terraces and floodplains were leveled by river flooding induced by melting of glaciers. They are dissected by high-energy, low-gradient, perennial streams. Channels may be braided. Channel deposits are usually comprised of moderately to well sorted sand to cobble size deposits but may include boulders. Ponds, marshes and overflow channels occur with a range of finer grained deposits. This landform is subject to frequent flooding. It has a high subsurface flow rate. Subsurface and instream flow may be in continuity. They are stable but soils on terrace escarpments may unravel. This landform commonly adjoins but can include alluvial fans and colluvial deposits along valley sides.

Glacial Till: A very dense, poorly sorted mixture of clay, silt, sand and gravel deposited directly beneath glacial ice.

Glides: Stream habitat having a slow, relatively shallow run of water with little or no surface turbulence.

Healthy Stock: A stock of fish experiencing production levels consistent with its available habitat and within the natural variations in survival for the stock.

Hydrologic Unit Code (HUC): classification system used to describe the sub-division of hydrologic units. The codes represent the four levels of classification in the hyrdrologic unit system. The first level divides the US into 21 major geographic areas, or regions, based on surface topography, containing the drainage area of a major river or series of rivers. The second level divides the 21 regions into 222 sub-regions, which includes the area drained by a river system, a reach of a river and its tributaries in that reach, a closed basin or, a group of streams forming a coastal drainage area. The third level subdivides many of the subregions into accounting units. These 352 units nest within, or are equivalent to, the sub-regions. The fourth level is the cataloging unit, a geographic area representing part or all of a surface drainage basin, a combination of basins, or a distinct hydrologic feature. These units subdivide the sub-regions and accounting units into approximately 2150 smaller areas.

Hydrograph: A graphic representation or plot of changes in the flow of water or in the elevation of water levels plotted against time.

Hydrology: Study of the properties, distribution, and effects of water on the Earth's surface, subsurface, and atmosphere.

Interagency Aquatic Database and GIS: contains Stream Inventory information from the USFS, Oregon Department of Fish and Wildlife, and the Bureau of Land Management and can be sorted by stream width and stream gradient.

Intermittent stream: Stream that has interrupted flow or does not flow continuously. Compare *perennial stream*.

Interstitial spaces: Space or openings in substrates that provide habitat and cover for bottom dwelling organisms, like young salmonids.

Intraspecific interactions: Interactions within a species.

Large Woody Debris (LWD): Any large piece of relatively stable woody material having a diameter greater than 10 cm and a length greater than 3 meters. LWD is an important part of the structural diversity of streams. The nature and abundance of LWD in a stream channel reflects past and present recruitment rates. This is largely determined by the age and composition of past and present adjacent riparian stands. Synonyms include: Large Organic Debris (LOD) and Coarse Woody Debris (CWD). Specific types of large woody debris include:

> Affixed logs: Singe logs or groups of logs that are firmly embedded, lodged, or rooted in a stream channel.
>
> Deadheads: Logs that are not embedded, lodged or rooted in the stream channel but are submerged and close to the surface.
>
> Digger log: Log anchored to the stream banks and/or channel bottom in such a way that a scour pool is formed.
>
> Free logs: Logs or groups of logs that are not embedded, lodged or rooted in the stream channel.
>
> Rootwad: The root mass of the tree.
>
> Snag: A standing dead tree, or, a sometimes a submerged fallen tree in large streams. The top of the tree is exposed or only slightly submerged.
>
> Sweeper log: Fallen tree whose bole or branches form an obstruction to floating objects.

Large Woody Debris Recruitment: The standing timber adjacent to the stream that is available to become large woody debris. Activities that disturb riparian vegetation including timber removal in riparian areas can reduce LWD recruitment. In addition, current conditions also reflect the past history of both natural and management-related channel disturbances such as flood events, debris flows, splash damming and stream clean-out.

Lateral Moraine: Hummocky, rolling glacial till deposits typically located in recesses along the mid-slopes of glacial trough walls. Slope is generally 25-40%. These deposits are usually not compacted. The slopes are dissected by poorly defined streams in a dendritic to deranged drainage pattern. They have a high subsurface water storage capacity and may be good shallow aquifers. Surface runoff is limited. Wet areas commonly occur in swales. Subsurface water is often diverted to depressional areas.

Late-Successional Reserves (LSR's): A land management designation for federally-administered lands within the range of the northern spotted owl (USFS and BLM 1994). Late-Successional Reserves are managed to protect and enhance conditions of late-successional and old-growth forest ecosystems, which serve as habitat for late-successional and old-growth forest related species including he northern spotted owl. Limited stand management is permitted.

Limiting Factor: Single factor that limits a system or population from reaching its highest potential.

Macroinvertebrates: Invertebrates large enough to be seen with the naked eye (e.g., most aquatic insects, snails, and amphipods).

Managed Late-Successional Reserves (MLSR): A land management designation for federally-administered lands within the range of the northern spotted owl (USFS and BLM 1994). Managed Late-Successional Reserves are identified for certain locations in drier provinces where regular and frequent fire is a natural part of the ecosystem. Like LSRs, MLSRs are managed to protect and enhance conditions of late-successional and old-growth forest ecosystems, which serve as habitat for late-successional and old-growth forest related species including he northern spotted owl. Certain silvicultural treatments and fire hazard reduction treatments are allowed to help prevent complete stand destruction from large catastrophic events such as high intensity, high severity fires; or diseased or insect epidemics.

Mass wasting: Landslide processes, including debris falls, debris slides, debris avalanches, debris flows, debris torrents, rockfalls, rockslides, slumps and earthflows, and all the small scale slumping collapse and raveling of road cuts and fills.

Matrix: A land management designation for federally-administered lands within the range of the northern spotted owl (USFS and BLM 1994). The matrix consists of those federal lands outside of the six categories of designated areas (Congressionally Reserved Areas, Late –Successional Reserves, Adaptive Management Areas, Managed Late-Successional Area, Administratively Withdrawn Areas, and Riparian Reserves). Most timber harvest and other silvicultural activities would be conducted in that portion of the matrix with suitable forest lands, according to standards and guidelines. Most timber harvest takes place in the matrix.

Moraine: See “Terminal Moraine”.

Native: Occurring naturally in a habitat or region; not introduced by humans.

Non-Point Source Pollution: Polluted runoff from sources that cannot be defined as discrete points, such as areas of timber harvesting, surface mining, agriculture, and livestock grazing.

Oligotrophic: Pertaining to a lake or other body of water characterized by extremely low nutrient concentrations such as nitrogen or phosphorous and resulting in very moderate productivity.

Parr: Young trout or salmon actively feeding in freshwater; usually refers to young anadromous salmonids before they migrate to the sea. See *smolt*.

Plunge pool: A pool created by water passing over or through a complete or nearly complete channel obstruction, and dropping vertically, scouring out a basin in which the flow radiates from the point of water entry.

Pocket water: A series of small pools surrounded by swiftly flowing water, usually caused by eddies behind boulders, rubble, or logs, or by potholes in the streambed.

Pool: Portion of a stream with reduced current velocity, often with deeper water than surrounding areas and with a smooth surface.

Pool:riffle ratio: Ratio of the surface area or length of pools to the surface area or length of riffles in a given stream reach, frequently expressed as the relative percentage of each category.

Population: Organisms of the same species that occur in a particular place at a given time. A population may contain several discrete breeding groups or stocks.

Productivity: A measure of habitat quality which varies by species and lifestage. Productivity is a density-independent measure of habitat quality. Examples include, water temperature, water discharge, channel complexity, riparian condition, etc.

Rain-on-snow events: The rapid melting of snow as a result of rainfall and warming ambient air temperatures. The combined effect of rainfall and snow melt can cause high overland stream flows resulting in severe hillslope and channel erosion.

Rearing habitat: Areas required for the successful survival to adulthood by young animals.

Recovery: The return of an ecosystem to a defined condition after a disturbance.

Redds: Nests made in gravel (particularly by salmonids) for egg deposition consisting of a depression that is created and the covered.

Rehabilitation: Returning to a state of ecological productivity and useful structure, using techniques similar or homologus in concept; producing conditions more favorable to a group of organisms or species complex, especially that economically and aesthetically desirable flora and fauna, without achieving the undisturbed condition.

Resident fish: Fish species that complete their entire life cycle in freshwater.

Riffle: Stream habitat having a broken or choppy surface (white water), moderate or swift current, and shallow depth.

Riparian: Pertaining to the banks and other adjacent, terrestrial (as opposed to aquatic) environs of freshwater bodies, watercourses, and surface-emergent aquifers, whose imported waters provide soil moisture significantly in excess of that otherwise available through local precipitation – soil moisture to potentially support a mesic vegetation distinguishable from that of the adjacent more xeric upland.

Riparian Area: The area between a stream or other body of water and the adjacent upland identified by soil characteristics and distinctive vegetation. It includes wetlands and those portions of floodplains which support riparian vegetation.

Riparian Habitat Conservation Areas (RHCA): Portions of watersheds where riparian-dependent resources receive primary emphasis, and management activities are subject to specific standards and guidelines. The RHCAs include traditional riparian corridors, wetlands, intermittent headwater streams, and other areas where proper ecological functioning is crucial to maintenance of the stream's water, sediment, woody debris and nutrient delivery systems (USFS AND BLM 1995/ PACFISH)

Riparian Reserves: A land management designation for federally-administered lands within the range of the northern spotted owl (USFS and BLM 1994/ Northwest Forest Plan). The Riparian Reserves provide an area along all stream, wetlands, ponds, lakes, and unstable and potentially unstable areas where riparian-dependent resources receive primary emphasis.

Riparian Vegetation: Terrestrial vegetation that grows beside rivers, streams and other freshwater bodies and that depends on these water sources for soil moisture greater than would otherwise be available from local precipitation.

Riprap: Large rocks, broken concrete, or other structure used to stabilize streambanks and other slopes.

Rootwad: Exposed root system of an uprooted or washed-out tree.

Run: An area of swiftly flowing water, without surface agitation or waves, which approximates uniform flow and in which the slope of the water surface is roughly parallel to the overall gradient of the stream reach.

SaSI (Salmonid Stock Inventory): A list of Washington's naturally reproducing salmonid stocks and their origin, production type, and status. Developed in 1998 as an appendix to SASSI to include bull trout and Dolly Varden; formerly named SASSI.

SASSI (Salmon and Steelhead Stock Inventory): A list of Washington's naturally reproducing salmon and steelhead stocks and their origin, production type, and status; developed in 1992.

SSHIAP (Salmon, Steelhead Habitat Inventory and Assessment Project): A partnership based information system that characterizes distribution and freshwater habitat conditions of salmonid stocks in Washington.

Salmonid: Fish of the family salmonidae, including salmon, trout chars, and bull trout.

Salmon: Includes all species of the family Salmonid

Sediment: Material carried in suspension by water, which will eventually settle to the bottom.

Sedimentation: The process of subsidence and deposition of suspended matter carried in water by gravity; usually the result of the reduction in water velocity below the point at which it can transport the material in suspended form.

Seral stages: Series of relatively transitory plant communities that develop with ecological succession from bare ground to the climax plant community stage.

Side channel: Lateral channel with an axis of flow roughly parallel to the mainstem, which is fed by water from the mainstem; a braid of a river with flow appreciably lower than the main channel. Side channel habitat may exist either in well defined secondary (overflow) channels or in poorly defined watercourses flowing through partially submerged gravel bars and islands along the margins of the mainstem.

Sinuosity: Degree to which a stream channel curves or meanders laterally across the land surface. Can be determined by the ratio of the stream length to valley floor, or, the ratio of the channel length between two points on a channel to the straight line distance between the same points.

Slope: Water surface slope is determined by measuring the difference in water surface elevation per unit stream length. Typically measured through at least twenty channel widths or two meander wavelengths.

Slope stability: The degree to which a slope resists the downward pull of gravity.

Smolt: Juvenile salmonid, 1 or more years old, migrating seaward; a young anadromous trout, salmon, or char undergoing physiological changes that will allow it to change from life in freshwater to life in the sea. The smolt stage follows the parr stage. See *parr*.

Stock: Group of fish that is genetically self-sustaining and isolated geographically or temporally during reproduction. Generally, a local population of fish. More specifically, a local population – especially that of salmon, steelhead (rainbow trout), or other anadromous fish – that originates from specific watersheds as juveniles and generally returns to its birth streams to spawn as adults.

Stream Number: A unique six-digit numerical stream identifier, with the first two digits representing the WRIA and the last four digits representing the unique stream identifier from the WDF Stream Catalog (Williams et al. 1975) where available. For streams where the Stream Catalog does not provide a stream identified: (1) unassigned numbers in the sequence are used; or (2) an additional single-character alpha extension may be added to the end of the four-digit stream identifier for the next downstream numbered stream. Alpha extensions are generally used for tributaries to a numerically identified stream proceeding from downstream to upstream.

Stream Order: A classification system for streams based on the number of tributaries it has. The smallest unbranched tributary in a watershed is designated Order 1. A stream formed by the confluence of two order 1 streams is designated Order 2. A stream formed by the confluence of two order 2 streams is designated Order 3; and so on.

Stream Reach: a homogeneous segment of a drainage network characterized by uniform channel pattern, gradient, substrate and channel confinement.

Substrate: mineral and organic material forming the bottom of a waterway or water body.

Subwatershed: One of the smaller watersheds that combine to form a larger watershed.

Supplementation: the collection, rearing, and release of locally adapted salmon in ways that promote ecologic and genetic compatibility with the naturally produced fish.

Terminal Moraine: A low-relief, linear deposit of glacial till. These occur on valley bottoms and are laid down at the terminal end of a glacier as forward progress ends and marks the furthest extension of the glacier. Moraines have moderate to high subsurface water storage capacity.

Terrace: Abandoned floodplain.

Thalweg: The path of maximum depth in a river or stream.

Watershed: An area so sloped as to drain a river and all its tributaries to a single point or particular area. The total area above a given point on a watercourse that contributes water to its flow.

Watershed restoration: Reestablishing the structure and function of an ecosystem, including its natural diversity; a comprehensive, long-term program to return watershed health, riparian ecosystems, and fish habitats to a close approximation of their condition prior to human disturbance.

Watershed-scale approach: Consideration of the entire watershed in a project or plan.

Weir: Device across a stream to divert fish into a trap or to raise the water level or divert its flow. Also a notch or depression in a dam or other water barrier through which the flow of water is measured or regulated.

Width-depth ratio: Describes the dimension and shape factor as the ratio of bankfull channel width to bankfull mean depth.

Wild Stock: A stock that is sustained by natural spawning and rearing in the natural habitat regardless.

APPENDIX A – FISH DISTRIBUTION MAPS FOR WRIA 50 AND 44

Several maps have been included with this report for your reference. The maps are appended to the report, either as a separate electronic file (for the electronic copy of this report) or separate printed section (for hard copy). The maps are included as a separate electronic file to enable the reader to utilize computer multi-tasking capabilities to simultaneously bring up the map and associated text. Below is a list of maps that are included in the WRIA 50 and 44 map appendix/file:

Appendix A1: Spring Chinook Salmon Distribution in the Foster Watershed, WRIA 50

Appendix A2: Spring Chinook Salmon Distribution in the Moses Coulee Watershed, WRIA 44

Appendix A3: Summer/ Fall Chinook Salmon Distribution in the Foster Watershed, WRIA 50

Appendix A4: Summer/ Fall Chinook Salmon Distribution in the Moses Coulee Watershed, WRIA 44

Appendix A5: Steelhead/Rainbow Trout Distribution in the Foster Watershed, WRIA 50

Appendix A6: Steelhead/Rainbow Trout Distribution in the Moses Coulee Watershed, WRIA 44

Appendix A7: Coho Salmon Distribution in the Foster Watershed, WRIA 50

Appendix A8: Coho Salmon Distribution in the Moses Coulee Watershed, WRIA 44

Appendix A9: Sockeye Salmon Distribution in the Foster Watershed, WRIA 50

Appendix A10: Sockeye Salmon Distribution in the Moses Coulee Watershed, WRIA 44

Appendix A11: Bull Trout Distribution in the Foster Watershed, WRIA 50

Appendix A12: Bull Trout Distribution in the Moses Coulee Watershed, WRIA 44

Appendix A13: All Species Salmonid Distribution WRIA 50

Appendix A14: All Species Salmonid Distribution WRIA 44

APPENDIX B - FISH DISTRIBUTION TABLES FOR WRIA 50 AND 44

Table B-1. Foster WRIA 50 Spring Chinook Distribution

WRIA Index	Stream Name	Species Use	Status	Data Source	Professional Observation Contact	Comments
50.0065	Foster Creek	Rearing	Known	Professional observation	Bob Steele, WDFW, Area Fish Biologist, Region 2, Wenatchee	Lower extent of known rearing in Foster Creek. Bob Steele electroshocked below the diversion dam in 1980 and found juvenile spring chinook (Bob Steele, 2000)
50.0065	Foster Creek	Rearing	Known	Professional observation	Bob Steele, WDFW, Area Fish Biologist, Region 2, Wenatchee	Upper extent of known rearing in Foster Creek up to diversion dam at RM 1.5 (Bob Steele, 2000)
50.0001	Columbia River	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Lower extent of known rearing and migratory use (Bob Steele, 2000). Lower extent is the WRIA 50 boundary.
50.0001	Columbia River	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Upper extent of known rearing and migratory use (Bob Steele, 2000). Upper extent is the Chief Joseph Dam.
50.0001	Columbia River	Rearing	Potential/ Historic	Professional observation	Bob Steele, WDFW, Area Fish Biologist, Region 2	Lower extent of potential/ historic rearing in the Columbia River assuming fish passage at Chief Joseph Dam. Lower extent begins at Chief Joseph Dam (Bob Steele, 2000).
50.0001	Columbia River	Rearing	Potential/ Historic	Professional observation	Bob Steele, WDFW, Area Fish Biologist, Region 2, Wenatchee	Upper extent of potential/ historic rearing in the Columbia River assuming fish passage at Chief Joseph Dam (Bob Steele, 2000) Upper extent WRIA 50 boundary

Table B-2. Moses Coulee WRIA 44 Spring Chinook Distribution

WRIA Index	Stream Name	Species Use	Status	Data Source	Professional Observation Contact	Comments
44.0002	Moses Coulee	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Lower extent of known rearing in the Moses Coulee when hydrology is present. Bob sampled this section in the 70s (Bob Steele, 2000)
44.0002	Moses Coulee	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Upper extent of known rearing in the Moses Coulee when hydrology is present (Bob Steele, 2000) Upper extent is one mile from the mouth.
44.0001	Columbia River	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Lower extent of known rearing and migratory use (Bob Steele, 2000). Lower extent WRIA 44 southern boundary
44.0001	Columbia River	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Upper extent of known rearing and migratory use (Bob Steele, 2000). Upper extent WRIA 44 northern boundary.
44.0630	Rock Island Creek	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Lower extent known rearing in Rock Island. Bob sampled this area in the 80s (Bob Steele, 2000)
44.0630	Rock Island Creek	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Upper extent known rearing in Rock Island Creek. Upper extent is ½-3/4 miles from the mouth. There is a spring here.(Bob Steele, 2000)

Table B-2. Moses Coulee WRIA 44 Spring Chinook Distribution

WRIA Index	Stream Name	Species Use	Status	Data Source	Professional Observation Contact	Comments
44.0756	Sand Canyon	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Lower extent known rearing in Sand Canyon Creek dependent upon irrigation flows. Irrigation flows are keeping this stream flowing. Bob Steele electroshocked from the mouth to the SR 28, ¼ mile up (Bob Steele, 2000)
44.0756	Sand Canyon	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Upper extent known rearing in Sand Canyon Creek dependent upon irrigation flows. Upper extent is ¼ mile up at SR 28. There is a culvert barrier/diversion dam here. (Bob Steele, 2000)

Table B-3. Foster WRIA 50 Summer/Fall Chinook Distribution

WRIA Index	Stream Name	Species Use	Status	Data Source	Professional Observation Contact	Comments
50.0065	Foster Creek	Rearing	Known	Professional observation	Bob Steele, WDFW, Area Fish Biologist, Region 2, Wenatchee	Lower extent of known rearing in Foster Creek. Bob Steele electroshocked below the diversion dam in 1980 and found juvenile summer/fall chinook (Bob Steele, 2000)
50.0065	Foster Creek	Rearing	Known	Professional observation	Bob Steele, WDFW, Area Fish Biologist, Region 2, Wenatchee	Upper extent of known rearing in Foster Creek up to diversion dam at RM 1.5 (Bob Steele, 2000)
50.0001	Columbia River	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Lower extent of known rearing and migratory use (Bob Steele, 2000). Lower extent is the WRIA 50 boundary.
50.0001	Columbia River	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Upper extent of known rearing and migratory use (Bob Steele, 2000). Upper extent is the Chief Joseph Dam.
50.0001	Columbia River	Spawning	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Lower extent chinook known (limited) spawning below Wells Dam, Chelan Falls, Chief Joseph Dam (Bob Steele, 2000)
50.0001	Columbia River	Spawning	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Upper extent chinook known (limited) spawning below Wells Dam, Chelan Falls, Chief Joseph Dam (Bob Steele, 2000). Upper extent Chief Joseph Dam.
50.0001	Columbia River	Rearing	Potential/ Historic	Professional observation	Bob Steele, WDFW, Area Fish Biologist, Region 2	Lower extent of potential/ historic rearing in the Columbia River assuming fish passage at Chief Joseph Dam. Lower extent begins at Chief Joseph Dam (Bob Steele, 2000).

Table B-3. Foster WRIA 50 Summer/Fall Chinook Distribution

WRIA Index	Stream Name	Species Use	Status	Data Source	Professional Observation Contact	Comments
50.0001	Columbia River	Rearing	Potential/ Historic	Professional observation	Bob Steele, WDFW, Area Fish Biologist, Region 2	Upper extent of potential/historic rearing in the Columbia River assuming fish passage at Chief Joseph Dam (Bob Steele, 2000) Upper extent WRIA 50 boundary
50.0001	Columbia River	Spawning	Potential/ Historic	Professional observation	Bob Steele, WDFW, Area Fish Biologist, Region 2	Lower extent of potential/ historic spawning in the Columbia River assuming fish passage at Chief Joseph Dam. Lower extent begins at Chief Joseph Dam (Bob Steele, 2000).
50.0001	Columbia River	Spawning	Potential/ Historic	Professional observation	Bob Steele, WDFW, Area Fish Biologist, Region 2	Upper extent of potential/ historic spawning in the Columbia River assuming fish passage at Chief Joseph Dam (Bob Steele, 2000) Upper extent WRIA 50 boundary.

Table B-4. Moses Coulee WRIA 44 Summer/ Fall Chinook Distribution

WRIA Index	Stream Name	Species Use	Status	Data Source	Professional Observation Contact	Comments
44.0002	Moses Coulee	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Lower extent of known rearing in the Moses Coulee when hydrology is present. Bob Steele sampled this creek in the 70s (Bob Steele, 2000).
44.0002	Moses Coulee	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Upper extent of known rearing in the Moses Coulee when hydrology is present. One mile up from mouth. (Bob Steele, 2000).
44.0001	Columbia River	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Lower extent of known rearing and migratory use (Bob Steele, 2000). Lower extent WRIA 44 southern boundary
44.0001	Columbia River	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Upper extent of known rearing and migratory use (Bob Steele, 2000). Upper extent WRIA 44 northern boundary.
44.0001	Columbia River	Spawning	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Chinook known limited spawning below Wells Dam, Chelan Falls, Chief Joseph Dam, Walla Walla Point (Bob Steele, 2000)
44.0001	Columbia River	Spawning	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Chinook known spawning near Walla Walla Point and the Wenatchee River fan (Bob Steele, 2000)
44.0630	Rock Island Creek	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Lower extent known rearing in Rock Island. Bob Steele sampled this creek in the 80s (Bob Steele, 2000),
44.0630	Rock Island Creek	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Upper extent known rearing in Rock Island up ½-3/4 miles up from mouth. There is a spring here (Bob Steele, 2000)

Table B-4. Moses Coulee WRIA 44 Summer/ Fall Chinook Distribution

WRIA Index	Stream Name	Species Use	Status	Data Source	Professional Observation Contact	Comments
44.0756	Sand Canyon	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Lower extent known rearing in Sand Canyon Creek dependent upon irrigation flows. Irrigation flows are keeping this stream flowing. Bob Steele electroshocked from the mouth to the SR 28, ¼ mile up (Bob Steele, 2000)
44.0756	Sand Canyon	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Upper extent known rearing in Sand Canyon Creek dependent upon irrigation flows. Upper extent is ¼ mile up at SR 28. There is a culvert barrier/diversion dam here. (Bob Steele, 2000)

Table B-5. Foster WRIA 50 Summer Steelhead/ Rainbow Trout Distribution

WRIA Index	Stream Name	Species Use	Status	Data Source	Professional Observation Contact	Comments
50.0065	Foster Creek	Rearing	Known	Professional observation	Bob Steele, WDFW, Area Fish Biologist, Region 2	Lower extent of known rearing in Foster Creek. Bob Steele electroshocked below the diversion dam in 1980 and found juvenile steelhead (Bob Steele, 2000)
50.0065	Foster Creek	Rearing	Known	Professional observation	Bob Steele, WDFW, Area Fish Biologist, Region 2	Upper extent of known rearing in Foster Creek up to diversion dam at RM 1.5 (Bob Steele, 2000)
50.0065	Foster Creek	Spawning	Known	Professional observation	Bob Steele, WDFW, Area Fish Biologist, Region 2	Lower extent of known spawning in Foster Creek. Bob Steele electroshocked below the diversion dam in 1980 and found juvenile steelhead (Bob Steele, 2000)
50.0065	Foster Creek	Spawning	Known	Professional observation	Bob Steele, WDFW, Area Fish Biologist, Region 2	Upper extent of known spawning in Foster Creek up to diversion dam at RM 1.5 (Bob Steele, 2000)
50.0001	Columbia River	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Lower extent of known rearing and migratory use (Bob Steele, 2000).Lower extent WRIA 50 boundary.
50.0001	Columbia River	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Upper extent of known rearing and migratory use (Bob Steele, 2000). Upper extent Chief Joseph Dam.
44.0001	Columbia River	Spawning	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Lower extent of potential spawning (limited, more likely to enter tributaries to spawn) (Bob Steele, 2000). Lower extent WRIA 44 southern boundary
44.0001	Columbia River	Spawning	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2,	Upper extent of potential spawning (limited, more likely to enter tributaries to spawn) (Bob Steele, 2000).

Table B-5. Foster WRIA 50 Summer Steelhead/ Rainbow Trout Distribution

WRIA Index	Stream Name	Species Use	Status	Data Source	Professional Observation Contact	Comments
					Wenatchee	Upper extent Chief Joseph Dam.
50.0001	Columbia River	Rearing	Potential/ Historic	Professional observation	Bob Steele, WDFW, Area Fish Biologist, Region 2	Lower extent of potential/ historic rearing in the Columbia River assuming fish passage at Chief Joseph Dam. Lower extent begins at Chief Joseph Dam (Bob Steele, 2000).
50.0001	Columbia River	Rearing	Potential/ Historic	Professional observation	Bob Steele, WDFW, Area Fish Biologist, Region 2	Upper extent of potential/ historic rearing in the Columbia River assuming fish passage at Chief Joseph Dam (Bob Steele, 2000)

Table B-6. Moses Coulee WRIA 44 Summer Steelhead/ Rainbow Trout Distribution

WRIA Index	Stream Name	Species Use	Status	Data Source	Professional Observation Contact	Comments
44.0002	Moses Coulee	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Lower extent of known rearing in the Moses Coulee when hydrology is present. Bob Steele sampled this creek in the 70s (Bob Steele, 2000).
44.0002	Moses Coulee	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Upper extent of known rearing in the Moses Coulee when hydrology is present one mile up from mouth (Bob Steele, 2000).
44.0002	Moses Coulee	Rearing	Potential	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Lower extent of potential rearing in the Moses Coulee when hydrology is present/ flood events (Bob Steele, 2000).
44.0002	Douglas Creek	Rearing	Potential	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Upper extent of potential rearing in the Moses Coulee when hydrology is present/flood events up to Douglas Creek (Bob Steele, 2000).
44.0001	Columbia River	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Lower extent of known rearing and migratory use (Bob Steele, 2000). Lower extent WRIA 44 southern boundary
44.0001	Columbia River	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Upper extent of known rearing and migratory use (Bob Steele, 2000). Upper extent WRIA 44 northern boundary.
44.0001	Columbia River	Spawning	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Lower extent of potential (limited, more likely to enter tributaries to spawn) (Bob Steele, 2000). Lower extent WRIA 44 southern boundary

Table B-6. Moses Coulee WRIA 44 Summer Steelhead/ Rainbow Trout Distribution

WRIA Index	Stream Name	Species Use	Status	Data Source	Professional Observation Contact	Comments
44.0001	Columbia River	Spawning	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Upper extent of potential (limited, more likely to enter tributaries to spawn) (Bob Steele, 2000). Upper extent WRIA 44 northern boundary.
44.0630	Rock Island Creek	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Lower extent known steelhead rearing in Rock Island (Bob Steele, 2000)
44.0630	Rock Island Creek	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Upper extent known steelhead rearing in Rock Island up ½-3/4 miles up from mouth (Bob Steele, 2000)
44.0630	Rock Island Creek	Spawning	Presumed	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Lower extent presumed steelhead spawning in Rock Island (Bob Steele, 2000)
44.0630	Rock Island Creek	Spawning	Presumed	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Upper extent presumed steelhead spawning in Rock Island up ½-3/4 miles up from mouth (Bob Steele, 2000)
44.0756	Sand Canyon	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Lower extent known rearing in Sand Canyon Creek dependent upon irrigation flows. Bob Steele electroshocked this creek in early-mid 90s from the mouth to highway. Irrigation flows are keeping this stream flowing. (Bob Steele, 2000)
44.0756	Sand Canyon	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Upper extent known rearing in Sand Canyon Creek dependent upon irrigation flows up ¼ mile to culvert barrier/ irrigation diversion (Bob Steele, 2000)

Table B-6. Moses Coulee WRIA 44 Summer Steelhead/ Rainbow Trout Distribution

WRIA Index	Stream Name	Species Use	Status	Data Source	Professional Observation Contact	Comments
44.0756	Sand Canyon	Spawning	Potential	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Lower extent potential spawning in Sand Canyon Creek dependent upon irrigation flows. Irrigation flows are keeping this stream flowing. (Bob Steele, 2000)
44.0756	Sand Canyon	Spawning	Potential	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Upper extent potential spawning in Sand Canyon Creek dependent upon irrigation flows (Bob Steele, 2000)
44.0779	Corbaley Canyon	Rearing	Potential	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Lower extent potential for anadromy based on flood events in Corbaley Canyon Creek. Bob Steele electroshocked juvenile rainbow/ steelhead up to horseshoe at approx. RM 6 in the fall of 1999. Lack of hydrology prevents access from the mainstream (Bob Steele, 2000)
44.0779	Corbaley Canyon	Rearing	Potential	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Upper extent potential for anadromy based on flood events in Corbaley Canyon Creek. Upper extent is at the horseshoe approx. RM 6 (Bob Steele, 2000)

Table B-7. Foster WRIA 50 Coho Distribution

WRIA Index	Stream Name	Species Use	Status	Data Source	Professional Observation Contact	Professional Observation Contact	Comments
50.0001	Columbia River	Rearing	Potential	Professional Knowledge	Chuck Peven, Chelan PUD, Fish and Wildlife Supervisor	Shane Bickford, Douglas PUD, Fish Biologist	Lower extent of potential/historic rearing and migratory use. Lower extent is the WRIA 50 southern boundary.
50.0001	Columbia River	Rearing	Potential	Professional Knowledge	Chuck Peven, Chelan PUD, Fish and Wildlife Supervisor	Shane Bickford, Douglas PUD, Fish Biologist	Upper extent of potential/historic rearing and migratory use. Upper extent is the Chief Joseph Dam.
50.0001	Columbia River	Rearing	Potential	Professional observation	Chuck Peven, Chelan PUD, Fish and Wildlife Supervisor	Shane Bickford, Douglas PUD, Fish Biologist	Lower extent of potential/ historic rearing in the Columbia River assuming fish passage at Chief Joseph Dam. Lower extent begins at Chief Joseph Dam.
50.0001	Columbia River	Rearing	Potential	Professional observation	Chuck Peven, Chelan PUD, Fish and Wildlife Supervisor	Shane Bickford, Douglas PUD, Fish Biologist	Upper extent of potential/ historic rearing in the Columbia River assuming fish passage at Chief Joseph Dam. Upper extent WRIA 50 boundary.

Table B-8. Moses Coulee WRIA 44 Coho Distribution

WRIA Index	Stream Name	Species Use	Status	Data Source	Professional Observation Contact	Professional Observation Contact	Comments
44.0001	Columbia River	Rearing	Potential	Professional Knowledge	Chuck Peven, Chelan PUD, Fish and Wildlife Supervisor	Shane Bickford, Douglas PUD, Fish Biologist	Lower extent of potential/ historic rearing and migratory use. Lower extent WRIA 44 southern boundary.
44.0001	Columbia River	Rearing	Potential	Professional Knowledge	Chuck Peven, Chelan PUD, Fish and Wildlife Supervisor	Shane Bickford, Douglas PUD, Fish Biologist	Upper extent of potential/ historic rearing and migratory use. Upper extent WRIA 44 northern boundary.

Table B-9. Foster WRIA 50 Sockeye Distribution

WRIA Index	Stream Name	Species Use	Status	Data Source	Professional Observation Contact 1	Professional Observation Contact 2	Comments
50.0001	Columbia River	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee		Lower extent of known rearing and migratory use (Bob Steele, 2000). Lower extent WRIA 50 southern boundary.
50.0001	Columbia River	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee		Upper extent of known rearing and migratory use (Bob Steele, 2000). Upper extent Chief Joseph Dam.
50.0001	Columbia River	Rearing	Potential/ Historic	Professional observation	Bob Steele, WDFW, Area Fish Biologist, Region 2	Chuck Jones, Douglas County Planner/ former Fish Biologist CCT	Lower extent of potential/ historic rearing in the Columbia River assuming fish passage at Chief Joseph Dam. Lower extent begins at Chief Joseph Dam (Bob Steele, 2000). Sockeye historically spawned in the Nespelem River (Chuck Jones, 2000)
50.0001	Columbia River	Rearing	Potential/ Historic	Professional observation	Bob Steele, WDFW, Area Fish Biologist, Region 2	Chuck Jones, Douglas County Planner/ former Fish Biologist CCT	Upper extent of potential/ historic rearing in the Columbia River assuming fish passage at Chief Joseph Dam (Bob Steele, 2000). Upper extent WRIA 50 boundary.

Table B-10. Moses Coulee WRIA 44 Sockeye Distribution

WRIA Index	Stream Name	Species Use	Status	Data Source	Professional Observation Contact	Comments
44.0001	Columbia River	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Lower extent of known rearing and migratory use (Bob Steele, 2000). Lower extent WRIA 44 southern boundary.
44.0001	Columbia River	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Upper extent of known rearing and migratory use (Bob Steele, 2000). Upper extent WRIA 44 northern boundary.

Table B-11. Foster WRIA 50 Bull Trout Distribution

WRIA Index	Stream Name	Species Use	Status	Data Source 1	Professional Observation Contact	Comments
50.0001	Columbia River	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Lower extent of known rearing area for bull trout. Bull trout are in all the pools in this reach (Bob Steele, 2000). Lower extent is the WRIA 50 southern boundary.
50.0001	Columbia River	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Upper extent of known rearing area for bull trout (Bob Steele, 2000). Upper extent Chief Joseph Dam
50.0001	Columbia River	Rearing	Known	Professional observation	Chuck Jones, Associate Planner Douglas County	Lower extent of known rearing in the Columbia River. Lower extent Chief Joseph Dam.
50.0001	Columbia River	Rearing	Known	Professional observation	Chuck Jones, Associate Planner Douglas County	Upper extent of known rearing in the Columbia River. Upper extent WRIA 50 boundary

Table B-12. Moses Coulee WRIA 44 Bull Trout Distribution

WRIA Index	Stream Name	Species Use	Status	Data Source	Professional Observation Contact	Comments
44.0001	Columbia River	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Lower extent of known rearing area for bull trout. Bull trout are in all the pools in this reach (Bob Steele, 2000).Lower extent WRIA 44 southern boundary
44.0001	Columbia River	Rearing	Known	Professional Knowledge	Bob Steele, WDFW Area Fish Biologist, Region 2, Wenatchee	Upper extent of known rearing area for bull trout (Bob Steele, 2000). Upper extent WRIA 44 northern boundary

APPENDIX C- SALMONID HABITAT CONDITION RATING STANDARDS FOR IDENTIFYING LIMITING FACTORS FOR THE FOSTER AND MOSES COULEE WATERSHED

Under the Salmon Recovery Act (passed by the legislature as House Bill 2496, and later revised by Senate Bill 5595), the Washington Conservation Commission (WCC) is charged with identifying the habitat factors limiting the production of salmonids throughout most of the state, using existing information to include professional knowledge. This information should guide Lead Entity groups and the Salmon Recovery Funding Board in prioritizing salmonid habitat restoration and protection projects seeking state and federal funds. Identifying habitat limiting factors requires a set of standards that can be used to compare the significance of different factors and consistently evaluate habitat conditions in each WRIA throughout the state.

In order to develop a set of standards to rate salmonid habitat conditions, several tribal, state, and federal documents that use some type of habitat rating system were reviewed (Table C-1). The goal was to identify appropriate rating standards for as many types of habitat limiting factors as possible, with an emphasis on those standards that could be applied to readily available data. Based on the review, it was decided to rate habitat conditions into three categories: Good, Fair, and Poor. For habitat factors for which there was wide agreement on how to rate habitat condition, the accepted standard was adopted by the WCC. For factors that had a range of standards among the documents reviewed, one of the set of standards was adopted. Where no standard could be found, a default rating standard was developed by the WCC Technical Coordinators charged with writing the Salmonid Habitat Limiting Factors Reports.

In some cases there may be local conditions that warrant deviation from the rating standards adopted by the WCC. This is acceptable as long as the justification and a description of the procedures that were followed are clearly documented in the limiting factors report. Habitat condition ratings specific to streams draining east of the Cascade crest were included where they could be found, but for many parameters standards were not available. Additional rating standards will be included as they become available. In the meantime, TAGs in these areas will need to work with the standards presented by the WCC or develop alternatives based on local conditions. Again, if deviating from these standards, the procedures followed should be clearly documented in the limiting factors report. Sources used for rating standards in this report are included in Table C-1. The ratings adopted by WCC as amended by the TAG are presented in Table C-2. -These ratings are not intended to be used as thresholds for regulatory purposes, but as a coarse screen to identify the most significant habitat limiting factors in a WRIA. They also will hopefully provide a level a consistency between WRIAs that allows habitat conditions to be compared across the state. However, for many habitat factors, there may not be sufficient data available to use a rating standard or there may be data on habitat parameters where no rating standard is provided. For these factors, the professional judgment of the TAG was used to assign the appropriate ratings.

Table C-1. Source documents

Code	Document	Organization
Hood Canal	Hood Canal/Eastern Strait of Juan de Fuca Summer Chum Habitat Recovery Plan, Final Draft (1999)	Point No Point Treaty Council, Skokomish Tribe, Port Gamble S'Klallam Tribe, Jamestown S'Klallam Tribe, and Washington Department of Fish and Wildlife
ManTech	An Ecosystem Approach to Salmonid Conservation, vol. 1 (1995)	ManTech Environmental Research Services for the National Marine Fisheries Service, the US Environmental Protection Agency, and the US Fish and Wildlife Service
NMFS	Coastal Salmon Conservation: Working Guidance for Comprehensive Salmon Restoration Initiatives on the Pacific Coast (1996)	National Marine Fisheries Service
PHS	Priority Habitat Management Recommendations: Riparian (1995)	Washington Department of Fish and Wildlife
Skagit	Skagit Watershed Council Habitat Protection and Restoration Strategy (1998)	Skagit Watershed Council
WSA	Watershed Analysis Manual, v4.0 (1997)	Washington Forest Practices Board
WSP	Wild Salmonid Policy (1997)	Washington Department of Fish and Wildlife
TAG	Professional knowledge of the Foster and Moses Coulee Watersheds Technical Advisory Group, meeting on 11/21/00.	Shane Bickford, fish biologist, Douglas PUD; Joe Kelly, fish biologist, USBLM; Chuck Jones, Douglas County Planning.

Table C-2. Salmonid habitat condition ratings for WRIA 44 & 50

Habitat Factor	Source	Parameter/Unit	Channel Type	Poor	Fair	Good
Access to Spawning and Rearing Habitat	WSA		All	Access blocked by low water, culvert, falls, temperature, etc.	-	No blockages
Floodplains and Channel Conditions	NMFS		All	severe reduction in hydrologic connectivity between off-channel, wetland, floodplain and riparian areas; wetland extent drastically reduced and riparian vegetation/succession altered significantly	reduced linkage of wetland, floodplains, and riparian areas to main channel; overbank flows are reduced relative to historic frequency, as evidenced by moderate degradation of wetland function, riparian vegetation/succession	off-channel areas are frequently hydrologically linked to main channel; overbank flows occur and maintain wetland functions, riparian vegetation and succession
Riparian Condition	TAG		All	little to no riparian vegetation	insufficient to withstand flood events	sufficient riparian to withstand high flood events

Habitat Factor	Source	Parameter/Unit	Channel Type	Poor	Fair	Good
Water Quality: Temperature	TAG		All	>18° C (64.4° F), maximum average	14-18° C (57.2° - 64.4 ° F), maximum average	<14° C (57.2°F), maximum average
Water Quantity	TAG		All	little to no water	intermittent, ephemeral, seasonal flow	perennial most years
Exotic and Opportunistic Species				Impacted by exotic and opportunistic species	-	No impacts by exotic and opportunistic species
Biological Process				Beaver activity diminished	-	Balanced beaver activity

APPENDIX D- HISTORICAL DESCRIPTIONS

Rock Island Creek

Written by Lucy Keane

In 1887 James E. Keane established his home ranch near the mouth of Rock Island Creek. Keane, a mining engineer from California, had scouted the area in 1885 and felt that this region had great possibilities for gold, silver, and clay mining; also good water transportation.

The Keane's family neighbors were a branch band of Chief Moses Indian tribe who wintered on Rock Island Creek near its mouth. At that time, reports indicate that Rock Island Creek was a serene pastoral setting, with intermittent large groves of cottonwood, aspen, sarvis (sic) berries, and other green lush growth. Keane's family cut winter wood in the groves and captured driftwood from the Columbia for fuel.

The Indians built their sweathouses on banks of Rock Island Creek and caught salmon for food in the Columbia River proper. No report from the family ever said that salmon were trapped or netted in Rock Island Creek itself. The creek provided water to grow many sarvis (sic) berry bushes which the Indians harvested as part of their diet, also digging camas, wild onions, and other root vegetables from the Rock Island Creek canyon floor.

James Keane built a water system for his alfalfa fields adjoining the creek. There was ample water available in the creek at that time for irrigation. The remnants of his metal irrigation pipes are still visible today.

Many beavers built dams in the upper reaches of the creek where resident rainbow trout fish were present. As homesteaders moved into the Rock Island Creek region and broke out wheat fields on lands draining into the creek, it was necessary to get the wheat to market, so a wagon road was built down Beaver Creek which intersects with Rock Island Creek approximately five miles above its mouth. This road also traversed Rock Island Creek, and allowed wheat wagons to reach either Waterville or Rock Island at Keane's Hammond mills. The Family also reported that early vintage cars also used this road passage.

After the Great Northern Railroad came to the region, many things changed in the Rock Island Creek area, especially near its mouth. Now a railroad bridge crossed the creek. An automobile bridge was also built. The Indians re-located on reservations, cattle and horses roamed the grasslands depleting the vegetation. Many cottonwood groves were also depleted by the voracious beavers; however Rock Island Creek was still a placid stream with easy movement through the canyon.

In June 1948, the entire Rock Island Creek run and watershed were devastated by four huge cloudbursts. Mother Nature changed the topography of the creek from a serene pastoral setting, to a harsh, barren, and forbidding wild flooded area. This all happened in about thirty minutes of downpour. Large boulders were hurled one hundred to two hundred feet out from the rock bluffs above the canyon floor just from the mighty force of the cloudburst. (My husband, father-in-law, and I were caught on the lower canyon slopes and observed this horrible flood and devastation as it happened.) The beaver dams on the upper reaches gave way adding to the volume of floodwater. When the storm cleared, the creek bed had been reduced to huge boulders, river rock, and some stretches of sand silt. No good soil was left intact. The road had been wiped out in both Beaver and Rock Island Creeks. Three more cloudbursts followed the initial devastation that year leaving very little soil in the lower eight miles of the creek. After 1948 much flooding occurred almost every year as the natural impediments, trees, bushes, and grasses no longer grew along the creek.

In 1957 due to frozen ground and an ice cover on the lands draining into the creek, an early Chinook took all the snow in a few hours. This flood was the most devastating, perhaps worse then 1948 because there was nothing to hinder its rampage. Cows and calves were washed to the river. Debris filled under the highway and railroad bridges threatening to demolish them. After the flood subsided, Great Northern Railroad did major re-construction on the creek channel and also constructed many diversion dykes in the first mile of the creek. Later floods proved these to be very ineffectual.

The greatest impact the floods had was the loss of a stable creek bed. Water went under ground earlier and earlier in the lower creek areas. Sometimes the creek disappeared in April or May, and sometimes did not run at all. Rock Island Creek would be dry for approximately five miles from its mouth northerly. This stopped the passage of any early spawning fish.

With the absence of surface water in the creek, Delbert Keane faced major problems to get winter water for his cowherd. It was decided in the late fifties to dig hoping to bring creek water to the surface. A water witch, Harold Monesmith, felt that there was a great amount of water in an area away from the creek channel. Thinking that perhaps the underground creek water had changed course away from the visible channel, Keane dug down approximately seven to ten feet and struck a large stream of water bubbling up from underground. He imbedded a concrete ring into the ground to stabilize the hole. This quantity of water still runs free flowing today.

Delbert Keane believed he had struck the creek stream until winter and sub-zero temperatures proved differently. The water never froze, even at twenty below zero, and remained a constant flow. Upon testing this proved to be an artesian water flow.

In summation, time has proved that Rock Island Creek consistently goes underground early due to the loss of the streambed. The floods continue to plague the area frequently. The riparian zone is constantly under threatening devastation. As an avid fisherman, I have never witnessed fish passage up the creek. I have observed the creek for fifty-three years and would have been happy to brag on large fish catches. There has also been years when there was no water running in the lower four miles. It seems that the creek water flow is now more dependent on snow melt than regular surface water. Mother Nature has done much to change Rock Island Creek from the tree-shaded, lush, inviting campground in the late 1800's and early 1900's to a rock-strewn, undependable, and barren creek. Any man-made attempts to change the present creek are met with harsh retaliation by Mother Nature.

Respectfully Submitted;

Lucy Keane (Mrs. Delbert)

Foster Creek

Written by Carol Gross

I live on West Foster Creek where the Mansfield road connects to Highway 17, 2 ½ miles south of Bridgeport.

My husband's parents settled at the north end of the 80 acres through which both West and East Foster Creek runs. In fact, the two creeks join together on this 80 acres. There were several years that family did not live here. Willard and I built our service station here at the beginning of the building of Chief Joseph Dam in 1950. Since there was a rock barrier and then a dam built ½ mile from the mouth of Foster Creek fish never came up through this property. We have not seen a fish since we moved here in June of 1951. There have been times when one or both creeks disappear underground. The floods have opened up springs which feed the creeks.

I know that fish have been planted above Leahy in East Foster and on the Dean Schmidt acreage which the game department purchased several years ago up West Foster Creek. After floods the contractors were instructed to place large boulders in the middle of the rebuilt channels for fish enhancement. Floods since have washed them down on our property and changed the flow of the creek.

I was raised at the north end of Jameson Lake. Born the daughter of Fred Wittig. The lake was much lower until about 1949 and was too alkali for fish until spring run-offs raised the lake several feet. I gave this report to my brother J.W. Wittig who still resides. The lake has risen so high that it has flooded many acres that my folks used for hay and truck gardening. J.W. has tried for several years to get a ditch at the lower end of the lake to drain it back away. They have lost two barns and our old home site in the lake. J.W. has documented and has pictures. I am enclosing some (information from him) and see him if you want more information.

Jameson Lake

Written by J.W. Wittig

First I would like to comment on Jameson Lake when we moved out here on Nov. 6, 1925. The lake reached up to about 17 or 1800 ft. of the house we lived in.

All the land around Moses Coulee had been farmed, being broke out from 1900 till 1906 a few parcels after that. With the ground cultivated the run-off increased and the lake level began to rise drowning out all but the extreme north end of the grove of trees seen in the 1881 drawing by Calvary officer Downing. By 1917 or 1918 dry years and poor crops caused almost all the early settlers to lose their homesteads. There was very little farming within six miles of Jameson Lake. The land went back to sagebrush. From 1925-1935 the lake dropped ten feet back near where it was at the time of the drawing in 1888. (Note the lowest paragraph on page 37 of 40) Then, in the coming of the tractor age in the mid 30's the ground was broke out again, most of it by the 50's in the Jameson Lake basin.

The green wheat is the first of run-off with the stubble next and the sagebrush last. Many years we have no run-off on the grass or sagebrush land when the cropland sheds water.

While the lower Moses Coulee had floods from the severe rainstorms, Jameson Lake did not. The Mansfield area recorded 28" of rain. May 1st, 1948 found 1 ½ feet of rise in the lake over May 1st, 1949.

In 1945, the first algae appeared in Jameson Lake. The lake at this time had risen about 15 feet over the low level of 1935, which was near the original level at the time of the drawing by Downing in 1881. In that year the lake would have measured about 5100 ft. in length, today it is over 16000 ft.

The average evaporation of Jameson Lake from 1925 through 1944 was about 3' each year. From that time on, due to water storage above Jameson Lake, it has dropped that figure to about 26" to 8" in a year.

1925 through 1935 Jameson Lake level dropped approximately 10'.

Readings from May 1 to May 1 each year were:

1936	2’ rise over 1935
1937	1’ rise over 1936
1938	.3’ rise over 1937
1939 & 1940	1 ½’ lower than 1938
1941	1 ½’ rise over 1940
1942	2’ rise over 1941
1943	1 ½ rise over 1942
1944	10” lower than 1943
1945	5’ rise over 1944
1946	3’ rise over 1945
1947	1’ lower than 1946
1948	(no run-off) 0’ rise of 1947
1949	(due to 28” of rain) 1 ½’ rise over 1948
1950	1 ½’ lower than 1949
1951	6’ rise over 1950
1952	0’ rise over 1951
1953	½’ rise over 1952
1954 & 1955	22” lower than 1953
1956	½’ rise over 1955
1957	4’ rise over 1956
1958	1 ½’ rise over 1957
1959	11’ rise over 1958

From 1936 through 1959 the lake level rose about 37 ½’. From 1960 until 1980 the lake level dropped 88”. From 1980 until Jan. 24, 1984, the lake level has risen 90 ½”. As of March 12, 1984 it has risen 105 ½”.

1985	Approx. 3” rise over 1984
1986	Remained the same
1987	2” lower than 1986
1988	10” lower than 1987

1988 Oct.	found it 37 ½” lower than the 1985 high
1989 April 3rd	found the lake 51” higher than ever before, it was at overflow 22” below
1990	found the lake 14” lower than overflow 32” below
1991	found the lake 22” lower than overflow 43” below
1992	found the lake 26” lower than overflow 48” below
1993	found the lake 18” lower than overflow 44” below
1994	found the lake 16” lower than overflow 43” below

The lake was measured in Oct. of 1994 and was 43” below overflow, the overall rise in Jan. through Feb. 2, 1995 was 127”.

1995 Feb. 1st	the lake level reached at least 84” above overflow.
1995 Oct. 28th	the lake level was 30 ½ below overflow.
1996 March	the lake level was 28” above overflow.
1996 Oct.	the lake was 10 ½” below overflow.